UNCLASSIFIED

AD NUMBER

ADB015244

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

FROM:

Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; 24 MAY 1976. Other requests shall be referred to Naval Weapons Center, China Lake, CA 93555.

AUTHORITY

USNWC notice, 5 Oct 1978

THIS PAGE IS UNCLASSIFIED

PIA-76-U634
RD-B 015 244

USADACS Technical Library
5 0712 01004620 8

TECHNICAL
LIBRARY

NWC TP 5864

Parametric Trajectory Program

by
John E. Peterson
Aircraft Armament Division
Systems Development Department

OCTOBER 1976

Distribution limited to U.S. Government agencies only; test and evaluation; 24 May 1976. Other requests for this document must be referred to the Naval Weapons Center.

Naval Weapons Center
CHINA LAKE, CALIFORNIA 93555

Naval Weapons Center

AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

R. G. Freeman, III, RAdm., USN . . . . . Commander

G. L. Hollingsworth . . . . . Technical Director

FOREWORD

The documentation of the computer program described in this report was performed during Fiscal Year 1976 and is a subproject supported by Naval Air Systems Command AirTask A350-350B/008B/4F32-353-505.

It is part of a continuing effort to describe and document methodologies for computer simulation of aeroballistic performance of small-caliber, gun-fired projectiles.

This report was reviewed for technical accuracy by Richard Compton.

Released by
M. M. ROGERS, *Head*
Systems Development Department
24 May 1976

Under authority of
G. L. HOLLINGSWORTH
Technical Director

NWC Technical Publication 5864

Published by . . . . . Technical Information Department
Manuscript 5362/MS 76-76
Collation . . . . . Cover, 38 leaves
First printing . . . . . 55 unnumbered copies

THIS REPORT HAS BEEN DELIMITED
AND CLEARED FOR PUBLIC RELEASE
UNDER DOD DIRECTIVE 5200.20 AND
NO RESTRICTIONS ARE IMPOSED UPON
ITS USE AND DISCLOSURE.

DISTRIBUTION STATEMENT A

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Date Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NWC TP 5864	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* Parametric Trajectory Program		5. TYPE OF REPORT & PERIOD COVERED Computer Program FY 1976
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR*(s)* John E. Peterson		8. CONTRACT OR GRANT NUMBER*(s)*
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Weapons Center China Lake, CA 93555		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AirTask A350-350B/008B/ 4F32-353-505
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE October 1976
		13. NUMBER OF PAGES 74
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Distribution limited to U.S. Government agencies only; test and evaluation; 24 May 1976. Other requests for this document must be referred to the Naval Weapons Center.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Guns
Ballistics
Trajectories
Trajectory Table Computer Programs

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

See back of form.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601 |

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Date Entered)*

(U) *Parametric Trajectory Program*, by John E. Peterson. China Lake, Calif., Naval Weapons Center, October 1976. 74 pp. (NWC TP 5864, publication UNCLASSIFIED.)

(U) This aeroballistic three-degree-of-freedom computer program was developed to predict trajectories of both air-fired and ground-fired projectiles, and to prepare trajectory tables to assist designers of new or experimental ordnance.

(U) It is an efficient and inexpensive program to run, and is thus valuable in preparing extensive data for analysis of the various projectile design parameters.

CONTENTS

INTRODUCTION

This report describes a three-degree-of-freedom particle trajectory program for calculation of range tables and trajectories for gun-fired projectiles. It has been designed to give maximum data coverage needed by the projectile designers and weapon effectiveness analysts, consistent with minimum computer time and cost. This permits large numbers of computer runs, at minimal cost, for parametric studies involving a number of design parameters, and for design optimization.

While this program was designed for the UNIVAC 1110 computer, it is written in standard FORTRAN IV, and is easily adapted for other computers using this language. The program is also designed for easy modification and, in actual practice, a large number of variations have been used for special requirements and conditions, such as the tail-chase and head-on firings, special atmospheric models, special input format, etc.

The accuracy of this program has been verified with "real life" data obtained from instrumented range firings, with the computed trajectory data agreeing within the experimental error of the instrumentation. However, in common with all three-degree-of-freedom programs, it does not give dynamic stability data. When this is needed, the six-degree-of-freedom programs must be used.

The primary feature of this program is to prepare trajectory tables in final form, ready for use as "masters" in reports and other publications. These tables include a total of 14 variables, as follows: time, altitude, velocity, horizontal range, slant range, trajectory drop, static moment coefficient per radian, drag, kinetic (impact) energy, yaw of repose, Mach number, spin, impact angle, and the gyroscopic stability factor.

The second feature of this program is the card output for use in various plotting programs. These card outputs permit complete flexibility in displaying a series of selected runs in parametric plots. While special plotting programs have been prepared for these card outputs, they are written for use with the DISSPLA plotting system, and will be described in a separate report.

PROGRAM DESCRIPTION

This three-degree-of-freedom point trajectory program was designed for use in preparing trajectory data for air-to-air, air-to-surface (strafing), or surface-to-surface firing conditions. It is written in standard FORTRAN IV and designed for use with the UNIVAC 1110 computer, but it should be usable with any computer using standard FORTRAN IV or V language. To reduce computer time and cost, subroutines were not used, and this makes the program very inexpensive to run.

The program consists of 283 cards for the basic program and 19 cards for the data deck. The program glossary is shown in Appendix A, and the program is listed in Appendix B. The input deck is described separately in this report.

Several versions of this basic program have been prepared and used by the author for special requirements, such as unusual atmospheric models, head-on and tail-chase firing conditions, etc. To aid the reader in preparing such special programs, a complete listing of the program line number references is shown in Appendix C, and a complete flow chart of the program is shown in Appendix D. Sample outputs and inputs are included in Appendixes E and F.

AEROBALLISTIC EQUATIONS

The basic equations for this parametric trajectory program are given below.

Drag Equations

$$D = (1/2)\ \rho V^2 S C_D$$

where

D = drag, lb

ρ = air density, slugs/ft^3

V = velocity, ft/s

S = frontal area, ft^2

C_D = drag coefficient

and

$$C_D = C_{D_o} + C_{D_o}(\delta_r)^2$$

where

C_D = drag coefficient
C_{D_o} = drag coefficient at zero yaw
δ_r = yaw of repose, rad

Note: For this program, the angle of attack and yaw of repose are considered equivalent.

Gyroscopic Stability Factor Equation

$$s_g = \frac{2(I_x)^2 p^2}{\pi \rho I_y d^3 V^2 C_{M_\alpha}}$$

where

s_g = gyroscopic stability factor
I_x = axial moment of inertia, slug-ft^2
I_y = transverse moment of inertia, slug-ft^2
p = roll rate, rad/s
d = diameter, ft
V = velocity, ft/s
C_{M_α} = static moment coefficient, per rad

Yaw of Repose Equation

$$\delta_r = \frac{I_x g p \cos \theta}{(\rho/2) S d C_{M_\alpha} V^3}$$

where

δ_r = yaw of repose, rad
I_x = axial moment of inertia, slug-ft^2
g = gravitational constant, ft/s^2
p = roll rate, rad/s
θ = trajectory angle, rad
ρ = air density, slug/ft^3
S = frontal area, ft^2
d = diameter, ft
C_{M_α} = static moment coefficient, per rad
V = velocity, ft/s

Trajectory Increments

$$\bar{V} = V_o + (A_o + A_t/4)\ \Delta t$$

$$\bar{\theta} = \theta_o - \cos\theta\ \Delta t/\bar{V}$$

$$A_t = -(g \sin\theta + D/m)$$

$$\Delta z = (\bar{V} \sin\theta)\ \Delta t$$

where

A = acceleration, ft/s^2
D = drag, lb
m = mass, slugs
V = velocity, ft/s
θ = trajectory angle
x = horizontal distance, ft
z = vertical distance, ft
g = gravitational constant, ft/s^2

STANDARD ATMOSPHERE

This program uses the ICAO standard atmosphere. A sea level pressure of 760 mm of mercury at a temperature of 15°C is assumed. This is equivalent to 14.69 psi and 59°F. The standard density of dry air at these standard conditions is 0.002378 slug/ft^3 (NACA 1942). The temperature variation with altitude is as follows:

Up to 36,500 ft

$$T = 59 - 0.00356\ h$$

where

T = temperature, °F

h = altitude (ft) above mean sea level (MSL)

Above 36,500 ft

Temperature is assumed to be a constant -70°F.

The acoustic velocity is given by the following equation:

$$V_a = 49.1\ \sqrt{460 + T}$$

where

V_a = acoustic velocity, ft/s

T = temperature, °F

INPUT DATA

The data input for this program is in the form of a 19-card input data deck for a normal individual computer run, as shown in Table 1. However, as noted in the table, additional runs are possible.

The program uses a 12-point "drag table," including both 12 points for the drag coefficient at zero yaw, and 12 points for the static moment coefficient, per rad. The program then interpolates the data as required between these points. For Mach numbers above or below the range of these data, the program uses a constant maximum or minimum value, i.e., the last data point. While it is possible to modify the program to accept fewer than 12 data points, experience has shown that at least this number should be used.

It is possible to make additional runs using the same general projectile configuration, but changing the firing conditions and/or the projectile weight, moments of inertia, or muzzle velocity. In this case, as shown in Table 1, cards 16-19 must be repeated.

TABLE 1. Input Data.

Symbol	Format	Description	Units
		Cards 1-12	
N	I2,8X	Drag table line number	
CDO(I,1)	F10.4	Mach number for CDO(I,2)	
CDO(I,2)	F10.4	Drag coefficient at zero yaw	
CMA(I,1)	F10.4	Mach number for CMA(I,2)	
CMA(I,2)	F10.4	Static moment coefficient, per rad	
		Card 13	
KEA	8X,I2	Rifling exit angle	degrees (portion)
KEB	8X,I2	Rifling exit angle	minutes (portion)
CG	F10.3	Center of gravity, from base	inches
		Card 14	
FFD	F10.5	Drag table scaling constant	(Note 1)
FFM	F10.5	Scaling constant	(Note 1)
CDD2	F10.5	Yaw-drag coefficient, per rad^2	
TWIST	F10.5	Rifling twist	calibers/turn
		Card 15	
CLP	F10.5	Roll damping moment coefficient, per rad/s	
DTM	F10.5	Time increment	seconds (Note 2)
DMM	F10.5	Projectile diameter	millimeters
CAL	F10.5	Projectile length	calibers
		Card 16	
TITLA	5A6	Title for card output	

See Notes at end of table.

TABLE 1. (Contd.)

Symbol	Format	Description	Units
		Card 17	
NTAB	I2,8X	Table number	
VKT	F10.1	Aircraft velocity	knots
QE	F10.1	Quadrant elevation (- for dive angle)	degrees (Note 3)
TEMP	F10.1	MSL temperature	°F
ZT	F10.1	Terminal or target elevation	feet (MSL)
ZO	F10.1	Firing elevation	feet (MSL)
		Card 18	
RIX	F10.7	Axial moment of inertia	lb-inch^2
RIY	F10.7	Transverse moment of inertia	lb-inch^2
WTO	F10.7	Projectile weight	pounds
VO	F10.2	Projectile velocity	ft/s
PINT	F10.2	Printout skip	(Note 4)
		Card 19	
JRUN	I2	Additional runs Last run ≤ 0 Additional runs > 0 For additional runs, repeat cards 16, 17, 18, & 19	

NOTES:

1. Drag table scaling constant multipliers. These are normally set at 1.0, i.e., the drag table applies to the round in question. If no drag table is available for the projectile, these scaling factors can be applied to drag tables for similar rounds. In that case, the FFD applies to the drag coefficient data, and FFM applies to the static moment coefficient data.
2. The time increment "DTM" is optional, but normally, a time increment of 0.1 second has been found adequate.
3. Quadrant elevation "QE" refers to the gun elevation relative to the horizontal. A positive QE represents elevation above the horizontal, and a negative QE represents a negative (down) elevation or dive angle.
4. The printout skip "PINT" permits printout at selected time intervals.

CARD OUTPUT

The program is designed to automatically prepare a card deck for use as input to various plotting routines. This card output prepares one card per data "line" in the main trajectory tables, and includes 10 variables, as follows: time, horizontal range, altitude (MSL), slant range, velocity, kinetic (impact) energy, trajectory drop, spin, impact angle, and gyroscopic stability factor (see Table 2).

These 10 variables are mainly of concern to the projectile designers and weapon effectiveness analysts, but the additional trajectory drop (trajectory drop relative to the line of sight for the gun) is of special interest to those concerned with gunsights and related effects.

Where this card output feature is not required, it can easily be eliminated by removing card No. 19, 130, and 277 in the main program.

The use of separate output decks for computer runs was found extremely valuable for parametric studies where comparison plots could be prepared for various combinations of calibers and/or projectile characteristics. Also, since various combinations of the 10 variables can be plotted, these card outputs are extremely flexible in fulfilling special plotting requirements.

TABLE 2. Card Output.

Symbol	Format	Description	Units
		Card 1	
TITLA	5A6	Title for identification	
		Card 2-N	
TIME	F7.2,1X	Time	seconds
X	F7.0,1X	Horizontal range	feet
Z	F7.0,1X	Altitude (MSL)	feet
SLNT	F7.0,1X	Slant range	feet
V	F6.1,1X	Velocity	ft/s
ENG	F8.0,1X	Kinetic energy	ft-lb
DH	F6.1,1X	Trajectory drop	feet
RPS	F7.0,1X	Spin	rev/s
TTT	F6.2,1X	Impact angle (versus horizontal)	degrees
SG	F6.2	Gyroscopic stability factor	

TYPICAL TRAJECTORY TABLE OUTPUT

The program is primarily designed to prepare trajectory tables in final form and ready for publication in reports, or for immediate use by projectile designers and weapon system effectiveness analysts. These tables print out the trajectory data, a total of 14 variables, in an easily read double-line format, at preset time increments. In the trajectory table example shown in Appendix E, a time increment of 0.1 s was used, but this time increment can be changed merely by changing the printout skip ("PINT") in card 18 of the input data deck.

The program as listed uses an altitude cutoff; i.e., the program stops when it reaches the specified target altitude. Changes can easily be made by qualified programmers for special requirements, such as maximum range cutoff; but, for most cases, the altitude cutoff has been satisfactory.

When the program reaches the cutoff point, it calculates the exact time, slant range, velocity, impact angle, spin, and the gyroscopic stability factor. This is then printed out at the end of the trajectory table.

A typical example of the trajectory table output is shown in Appendix E, which is the output generated by the input listed in Appendix F. This example also shows the additional data printed at the end of each trajectory table, including ballistic data, drag table, and legend.

BIBLIOGRAPHY

Army Materiel Command. *Design for Control of Projectile Flight Characteristics*. Washington, D.C., Headquarters AMC, September 1966. AMC Engineering Handbook Series No. 242.

Naval Weapons Center. *Calculations of Gyroscopic Stability Factor for Various 20mm General Purpose Projectile (GPP) Configurations*, by John E. Peterson. China Lake, Calif., NWC, 27 February 1966. (NWC TN 3011-109.)

Naval Weapons Center. *NWC Trajectory Computer Program; verification of*, by J. E. Peterson. China Lake, Calif., 27 July 1973. (Memorandum 5115/JEP:pas, Serial 75.)

Appendix A

PROGRAM GLOSSARY

Program	Definition	Symbol	Unit
ACC	Projectile acceleration along trajectory at start of Δt	A_o	ft/s^2
ACCT	Projectile acceleration along trajectory at end of Δt	A_t	ft/s^2
CAL	Projectile length	cal	calibers
CD	Drag coefficient	C_D	
CDD2	Yaw-drag coefficient, per rad^2	$C_{D\delta 2}$	
CDO(I,1)	Mach number element in drag table (see text)	M	
CDO(I,2)	Drag coefficient element in drag table (see text)	C_{D_o}	
CDH	Tangent of angle theta	tan θ	
CG	Center of gravity, from base	CG	inches
CLP	Roll damping moment coefficient, per rad/s	C_{l_p}	
CM	Static moment coefficient, per rad (interpolated)	C_{M_α}	
CMA	Static moment coefficient, per rad (table input)	C_{M_α}	
CMA(I,1)	Mach number element in drag table (see text)	M	
CMA(I,2)	Static moment coefficient, per rad in drag table	C_{M_α}	
D	Maximum body diameter	d	feet
DH	Trajectory drop		feet
DIST	Arc distance along trajectory	s	feet

Program	Definition	Symbol	Unit
DMM	Projectile diameter	mm	millimeters
DRAG	Projectile drag	D	pounds
DS	Arc distance traveled during Δt	ΔS	feet
DT	Length of time increment	Δt	seconds
DTM	Time increment (input)	Δt	seconds
ENG	Kinetic energy	KE	ft-lb
FFD	Scaling ratio for drag curve (see text)		
FFM	Scaling ratio for drag curve (see text)		
GACC	Projectile acceleration along trajectory due to gravity	g_s	ft/s^2
GNU	Projectile spin	ν	rad/caliber
JRUN	Number of runs		
KEA	Rifling exit angle	ϕ_1	degrees
KEB	Rifling exit angle	ϕ_2	minutes
NTAB	Table number (printout)		
PINT	Printout counter skip		
PINTT	Printout counter		
QE	Quadrant elevation	θ	degrees
RGA	Axial radius of gyration	k_a	calibers
RGT	Transverse radius of gyration	k_t	calibers
RHO	Ratio of air densities at altitude and at sea level	ρ/ρ_o	
RH005	One-half air density at sea level at temperature T	$(1/2)\rho$	$slugs/ft^3$

Program	Definition	Symbol	Unit
RIX	Axial moment of inertia	I_x	lb-inch^2
RIXS	Axial moment of inertia	I_x	slug-ft^2
RIY	Transverse moment of inertia	I_y	lb-inch^2
RIYS	Transverse moment of inertia	I_y	slug-ft^2
RPS	Projectile spin	RPS	rev/s
S	Frontal area of projectile	A	ft^2
SG	Gyroscopic stability factor	s_g	
SGC	Computation constant for gyroscopic stability factor		
SLNT	Slant range		feet
TEMP	Air Temperature	T	°F
TEMPR	Ratio of standard absolute temperature to absolute air temperature		
THBAR	Average trajectory angle for Δt	$\bar{\theta}$	radians
THETA	Trajectory angle at end of Δt	θ_+	radians
THT	Sign carrying variable for surface-to-surface maximum trajectory elevation		
TIME	Time after firing	t	seconds
TITLA	Title for card output		
TTT	Theta angle converted to degrees		degrees
TWIST	Rifling twist	η	calibers/turn
V	Velocity	V	ft/s
VAO	Sea level velocity of sound at temperature T	V_{a_o}	ft/s

Program	Definition	Symbol	Unit
VBAR	Average velocity over Δt	$\bar{V}$	ft/s
VKT	Aircraft velocity	kt	knots
VM	Mach number	M	
VO	Muzzle velocity	V_o	ft/s
WGI	Projectile weight	gr	grains
WGR	Projectile weight	gm	grams
WS	Projectile mass	m	slugs
WTO	Projectile weight	W	pounds
X	Horizontal range	x	feet
YAW	Yaw of repose	δ_r	degrees
YR	Yaw of repose	δ_r	radians
YRC	Computation constant for yaw of repose		
Z	Projectile altitude (above MSL)	z	feet
ZF	Altitude for testing end of trajectory	z_f	feet
ZO	Gun altitude (above MSL)	z_o	feet
ZT	Target altitude (above MSL)	z_t	feet

Appendix B
PROGRAM LISTING

This Appendix contains the program listing. The input deck is described separately.

```
-RUN    143111,XXXXXXXXXX50,4022TRAXX,01,299/900    PETERSON 2505
-FOR,IS ,TRAXX
C       TRAJECTORY PROGRAM - JOHN L. PETERSON CODE 4022                  1
        DIMENSION TITLA(5)                                               2
        DIMENSION CDO(12,12), CMA(12,12)                                 3
C       INPUT DATA                                                       4
        DO 11 I = 1,12                                                   5
        READ(5,110) N, CDO(I,1), CDO(I,2), CMA(I,1), CMA(I,2)            6
   11   CONTINUE                                                         7
  110   FORMAT(I2,6X,4F10.4)                                             8
  120   FORMAT (6X,I2,6X,I2,F10.3)                                       9
        READ (5,120) KEA,KEB,CC                                         10

        READ(5,305) FFD,FFM,CDD2,TWIST                                  11
        READ(5,305) CLP,DTM,DMM,CAL                                     12
        READ(5,304) TITLA                                               13
  304   FORMAT(5A6)                                                     14
  305   FORMAT(4F10.5)                                                  15
        READ(5,310) NTAB,VKT,QE,TEMP,ZT,ZO                              16
  310   FORMAT(I2,6X,5F10.1)                                            17
        READ(5,311) RIX,RIY,WTO,VO,PINT                                 18
        WRITE(7,706) TITLA, NTAB                                        19
  706   FORMAT(5A6,5X,6HTABLE ,I2)                                      20

  311   FORMAT(3F10.7,2F10.2)                                           21
  200   CONTINUE                                                        22
C       INITIALIZATION                                                  23
        D = DMM * 0.0032808                                             24
        TEMPR = 510./(459.+TEMP)                                        25
        VAC = 1116./(TEMPR**0.5)                                        26
        RHOOS = .002169*TEMPR                                           27
        WS = WTO/32.174                                                 28
        WOS = SQRT(WS)                                                  29
        RIXS = RIX/(32.174*144.0)                                       30
```

```
      RIYS = RIY/(32.174*144.0)                                          51
      RKAY = 1.0/(D**.5)                                                 52
      RGA = RKAY * SQRT(RIXS)                                            53
      RGT = RKAY * SQRT(RIYS)                                            54
      PINIT = 0.0                                                        55
      ND = 0                                                             56
      TIME = 0.0                                                         57
      X = 0.0                                                            58
      DH = 0.0                                                           59
      DIST = 0.0                                                         60

      SLNT = 0.0                                                         61
      THT = QE                                                           62
      Z = Z0                                                             63
      IF(QE) 21,22,22                                                    64
   21 ZF = ZT                                                            65
      GO TO 23                                                           66
   22 ZF = Z0                                                            67
   23 S = .7854*D**2                                                     68
      WGT = 7000.0*WTO                                                   69
      WGK = 453.5924*WTO                                                 70

      THETA = 0.01745329*QE                                              71
      COM = TAN(THETA)                                                   72
      V = V0 + (1.689*VKT)                                               73
      SGC = RGA**4/(4.0*RHO05*S*D*RGT**2)                                74
      GNU = (6.2832/TWIST)*(V0/V)                                        75
      RPS = GNU * V * 2.425526                                           76
      YRC = 32.17*RGA**2/(RHO05*S)                                       77
C     MAIN PROGRAM                                                       78
      WRITE(6,14) NIAB                                                   79
      WRITE(6,15) Z0,QE                                                  80
```

```
      WRITE(6,16) VKI,TEMP                                                    61
   14 FORMAT(1H1,29X,23HTRAJECTORY TABLE NUMBER,I3//)                         62
   15 FORMAT(19X,9HALTITUDE-,F8.1,5H FEET,10X,8HAGE-,F8.1,8H DEGREES/)        63
   16 FORMAT(19X,9HVELOCITY-,F8.1,5H KTAS,10X,5HTEMP-,F6.1,6H DEG F//)        64
      WRITE(6,150)                                                            65
  150 FORMAT(14X,4HTIME,6X,1HX,6X,4HDIST,7X,1HV,                              66
     17X,2HDH,7X,3HCMA,7X,3HENG)                                              67
      WRITE(6,160)                                                            68
  160 FORMAT(14X,5HTHETA,5X,1HZ,6X,4HDRAG,6X,3HYAW,                           69
     15X,4HMACH,6X,4HSPIN,6X,2HSG/)                                           70

   31 IF (Z-30000.) 32,33,33                                                  71
   32 RHO = EXP(-3.2E-05*Z)                                                   72
      GO TO 34                                                                73
   33 RHO = .30269*EXP(-4.0E-05*(Z-30000.))                                   74
   34 IF (Z-36500.) 35,36,36                                                  75
   35 VM = V/(VAU-(VAU-970.)*Z/36500.)                                        76
      GO TO 37                                                                77
   36 VM = V/970.                                                             78
   37 IF(CDO(12,1)-VM) 38,38,390                                              79
   38 CD = CDO(12,2)                                                          80

      GO TO 43                                                                81
  390 IF(CDO(1,1)-VM)39,391,391                                               82
  391 CD = CDO(1,2)                                                           83
      GO TO 43                                                                84
   39 I = 2                                                                   85
   40 DIFF = VM - CDO(1,1)                                                    86
      IF (DIFF) 41,41,42                                                      87
   41 CD = CDO(1,2)+DIFF*(CDO(1,2)-CDO(I-1,2))/(CDO(1,1)-CDO(I-1,1))          88
      GO TO 43                                                                89
   42 I = I + 1                                                               90
```

```
      GO TO 40                                                          91
   43 CD = FFD*CD                                                       92
   44 IF (CMA(12,1)-VM) 45,45,460                                       93
   45 CM = CMA(12,2)                                                    94
      GO TO 50                                                          95
  460 IF(CMA(1,1)-VM)46,461,461                                         96
  461 CM = CMA(1,2)                                                     97
      GO TO 50                                                          98
   46 I = 2                                                             99
   47 DIFF = VM - CMA(I,1)                                             100

      IF(DIFF) 48,48,49                                                101
   48 CM = CMA(1,2)+DIFF*(CMA(1,2)-CMA(I-1,2))/(CMA(1,1)-CMA(I-1,1))   102
      GO TO 50                                                         103
   49 I = I + 1                                                        104
      GO TO 47                                                         105
   50 CM = FFM*CM                                                      106
C     GYROSCOPIC STABILITY FACTOR CALCULATION                          107
      SG = SGC*(GNU**2)*WS/(RHO*CM)                                    108
C     YAW OF REPOSE CALCULATION                                        109
   53 YR = (YRC*WS*GNU/(RHO*CM*V**2))*COS(THETA)                       110

      YAW = YR/.01745329                                               111
C     DRAG CALCULATIONS                                                112
      CD = CD + CDD2*YR**2                                             113
      GACC = -32.17*SIN(THETA)                                         114
      DRAG = RHOD3*RHO*(V**2*S*CD)                                     115
      ACC = GACC - DRAG/WS                                             116
      ENG = 0.5*WS*(V**2)                                              117
      DT = DTM                                                         118
C     TEST FOR TOP OF TRAJECTORY (SURFACE FIRE)                        119
      TTT = THETA/.01745329                                            120
```

```
     56 IF((THI*THETA) 70,70,55                                          121
     70 ZF = ZI                                                          122
C       PRINT-OUT COUNTER                                                123
     55 PINTT = PINTT - 1.0                                              124
        IF (PINTT) 57,64,64                                              125
     57 WRITE(6,81) TIME,X,SLNI,V,DM,CM,ENG                              126
     81 FORMAT(12X,F7.2,F9.0,F9.0,F9.1,F8.1,F9.2,F9.0)                   127
        WRITE(6,82) ITT,Z,DRAG,YAW,VM,RPS,SG                             128
     82 FORMAT(12X,F7.2,F9.0,F8.3,F10.4,F6.2,F9.0,F9.2/)                 129
        WRITE(7,707) TIME,X,Z,SLNI,V,ENG,DM,RPS,ITT,SG                   130

    707 FORMAT(F7.2,1X,F7.0,1X,F7.0,1X,F7.0,1X,F6.1,1X,F6.0,1X,          131
       1F6.1,1X,F7.0,1X,F6.2,1X,F6.2)                                    132
        ND = ND + 1                                                      133
        IF (12-ND) 91,91,92                                              134
     91 WRITE(6,89) NTAB                                                 135
     89 FORMAT(1H1,25X,23HTRAJECTORY TABLE NUMBER,13,8H (CON-T)//)       136
        WRITE(6,15) ZO, GE                                               137
        WRITE(6,16) VKT, TEMP                                            138
        ND = 0                                                           139
        PINTT = PINI                                                     140

        WRITE(6,150)                                                     141
        WRITE(6,160)                                                     142
     92 CONTINUE                                                         143
        PINTT = PINI                                                     144
C       CALCULATIONS FOR NEXT TRAJECTORY INCREMENT                       145
     64 DRAG = DRAG*(1.0+2.0*ACC*DT/V)                                   146
        ACCT = GACC - DRAG/WS                                            147
        VBAR = V + (ACC + ACCT)*DT/4.0                                   148
        DS = VBAR*DT                                                     149
        V = 2.0*VBAR-V                                                   150
```

```
      DIST = DIST + DS                                                    151
      TIME = TIME + DT                                                    152
      THT = THETA                                                         153
      THBAR = THETA - 16.09*COS(THETA)*DT/VBAR                            154
      X = X + DS*COS(THBAR)                                               155
      Z = Z + DS*SIN(THBAR)                                               156
      DH = X * CDH + ZO - Z                                               157
      SLNT = SQRT(((ZO - Z)**2)+(X**2))                                   158
      THETA = THETA - 32.17*COS(THBAR)*DT/VBAR                            159
      GNO = GNO*(1.0+((DRAG*CLP/(WS*CD*RGA**2))-ACCT)*DT/V)               160

C     RPS (REV/SEC) = GNO * V * 304.8006 / (2PI * 20.0)                   161
      RPS = GNO * V * 2.429526                                            162
C     TEST FOR END OF TRAJECTORY                                          163
      IF(Z-ZF) 67,67,99                                                   164
C     SAFETY - MAX TIME OF FLIGHT 200 SECONDS                             165
   99 IF(200.0-TIME) 67,67,31                                             166
C     END OF FLIGHT CALCULATIONS                                          167
   67 DS = (ZT-Z)/SIN(THETA)                                              168
      TIME = TIME + DS/V                                                  169
      X = X + DS*COS(THETA)                                               170

      SLNT = SQRT(((ZO - ZT)**2)+(X**2))                                  171
      THETA = THETA/.01745329                                             172
      WRITE(6,93)                                                         173
   93 FORMAT(14X,6HTIME,5EC,4X,6HRANGE,4T,5X,                             174
     17HVEL,4PS,4X,5HTHETA,5X,4HSPIN,3X,2HSG)                             175
      WRITE(6,83) TIME,SLNT,V,THETA,RPS,SG                                176
   83 FORMAT(12X,F9.2,2F12.1,F10.1,F9.0,F7.2)                             177
  777 CONTINUE                                                            178
      WRITE(6,89) NTAB                                                    179
      WRITE(6,315)                                                        180
```

```
315 FORMAT(1H ,1H /)                                                    181
    WRITE(6,330)                                                        182
330 FORMAT(1H ,35X,14HBALLISTIC DATA//)                                 183
    WRITE(6,315)                                                        184
    WRITE(6,320) DMM                                                    185
320 FORMAT(15X,19HPROJECTILE DIAMETER,17X,F10.2,2X,10HMILLIMETER//)     186
    WRITE(6,322) CAL                                                    187
322 FORMAT(15X,17HPROJECTILE LENGTH,21X,F10.1,2X,8HCALIBERS//)          188
    WRITE(6,331) WTO                                                    189
    WRITE(6,332) WGI                                                    190

    WRITE(6,333) WGR                                                    191
331 FORMAT(15X,17HPROJECTILE WEIGHT,23X,F10.7,2X,6HPOUNDS//)            192
332 FORMAT(55X,F10.2,2X,6HGRAINS//)                                     193
333 FORMAT(55X,F10.2,3X,5HGRAMS//)                                      194
    WRITE(6,366) RIX                                                    195
366 FORMAT(15X,23HAXIAL MOMENT OF INERTIA,9X,F10.7,                     196
   12X,14HPOUND-INCH SQ.//)                                             197
    WRITE(6,368) RIY                                                    198
368 FORMAT(15X,28HTRANSVERSE MOMENT OF INERTIA,4X,F10.7,                199
   12X,14HPOUND-INCH SQ.//)                                             200

    WRITE(6,334) RGA                                                    201
334 FORMAT(15X,24HAXIAL RADIUS OF GYRATION,14X,F10.7,2X,8HCALIBERS//)   202
    WRITE(6,336) RGT                                                    203
336 FORMAT(15X,29HTRANSVERSE RADIUS OF GYRATION,9X,F10.7,2X,            204
   18HCALIBERS//)                                                       205
    WRITE (6,337) CG                                                    206
337 FORMAT (15X,26HCENTER OF GRAVITY, FROM BASE,13X,F10.3,7H INCHES//)  207
    WRITE(6,338) VO                                                     208
338 FORMAT(15X,15HMUZZLE VELOCITY,20X,F10.1,2X,11HFEET/SECOND//)        209
    WRITE(6,340) TWIST                                                  210
```

```
340 FORMAT(15X,12HBARREL TWIST,21X,F10.5,2X,13HCALIBERS/TURN//)          211
    WRITE (6,341) KEA,KEB                                               212
341 FORMAT (15X,18HRIFLING EXIT ANGLE,19X,I2,9H DEGREES ,I2,            213
   +8H MINUTES//)                                                       214
    WRITE(6,342) CDD2                                                   215
342 FORMAT(15X,40HYAW-DRAG COEFFICIENT, PER RADIAN SQUARED,             216
   18X,F10.1//)                                                         217
    WRITE(6,344) CLP                                                    218
344 FORMAT(15X,44HROLL DAMPING MOMENT COEFFICIENT, PER RAD/SEC,         219
   14X,F10.4//)                                                         220

    WRITE(6,69) NTAB                                                    221
    WRITE(6,15) Z0,WE                                                   222
    WRITE(6,16) VKT,TEMP                                                223
    WRITE(6,346)                                                        224
346 FORMAT(1H ,10X,                                                     225
   152HDRAG COEFFICIENT AND STATIC MOMENT COEFFICIENT TABLE//)           226
    WRITE(6,348)                                                        227
348 FORMAT(20X,4HMACH,7X,3HCDO,6X,4HMACH,6X,3HCMA//)                    228
350 FORMAT(14X,F10.2,F10.3,F10.2,F10.3/)                                229
    DO 395 I=1,12                                                       230

    WRITE(6,350) CDO(I,1),CDO(I,2),CMA(I,1),CMA(I,2)                    231
395 CONTINUE                                                            232
400 FORMAT(1H1,35X,6HLEGEND//)                                          233
    WRITE(6,315)                                                        234
401 FORMAT(15X,4HTIME,11X,23HTIME OF FLIGHT, SECONDS//)                 235
402 FORMAT(15X,1HX,14X,22HHORIZONTAL RANGE, FEET//)                     236
403 FORMAT(15X,4HDIST,11X,17HSLANT RANGE, FEET//)                       237
404 FORMAT(15X,1HV,14X,21HVELOCITY, FEET/SECOND//)                      238
405 FORMAT(15X,2HDH,13X,16HGRAVITY DROP, FEET//)                        239
406 FORMAT(15X,5HCMA,12X,25HSTATIC MOMENT COEFFICIENT//)                240
```

```
  407 FORMAT(15X,3HENG,12X,19HENERGY, FOOT-POUNDS//)                    241
  408 FORMAT (15X,5HTHETA,10X,21HIMPACT ANGLE, DEGREES//)               242
  409 FORMAT(15X,1HZ,14X,14HALTITUDE, FEET//)                           243
  410 FORMAT(15X,4HDRAG,11X,12HDRAG, POUNDS//)                          244
  411 FORMAT(15X,3HYAW,12X,22HYAW OF REPOSE, DEGREES//)                 245
  412 FORMAT(15X,4HMACH,11X,11HMACH NUMBER//)                           246
  413 FORMAT(15X,4HSPIN,11X,18HREVOLUTIONS/SECOND//)                    247
  414 FORMAT(15X,2HSG,13X,27HGYROSCOPIC STABILITY FACTOR//)             248
  415 FORMAT(15X,4HTEMP,11X,25HSURFACE (MSL) TEMPERATURE//)             249
  416 FORMAT(15X,4HQ.E.,11X,19HDIVE ANGLE, DEGREES//)                   250

      WRITE(6,400)                                                      251
      WRITE(6,401)                                                      252
      WRITE(6,402)                                                      253
      WRITE(6,403)                                                      254
      WRITE(6,404)                                                      255
      WRITE(6,405)                                                      256
      WRITE(6,406)                                                      257
      WRITE(6,407)                                                      258
      WRITE(6,408)                                                      259
      WRITE(6,409)                                                      260

      WRITE(6,410)                                                      261
      WRITE(6,411)                                                      262
      WRITE(6,412)                                                      263
      WRITE(6,413)                                                      264
      WRITE(6,414)                                                      265
      WRITE(6,415)                                                      266
      WRITE(6,416)                                                      267
  352 CONTINUE                                                          268
C     ADDITIONAL RUNS                                                   269
      READ(5,301) JRUN                                                  270
```

```
 301 FORMAT(I2)
     IF(JRUN) 444,444,302
 302 CONTINUE
     READ(5,304) TITLA
     READ(5,310) NTAB,VKT,QE,TEMP,Z1,Z0
     READ(5,311) RIX,RIY,WTO,VO,PINT
     WRITE(7,700) TITLA, NTAB
     GO TO 200
 444 WRITE(6,95)
  95 FORMAT(1H1,1H //////)

     CALL EXIT
     END
-XQT
```

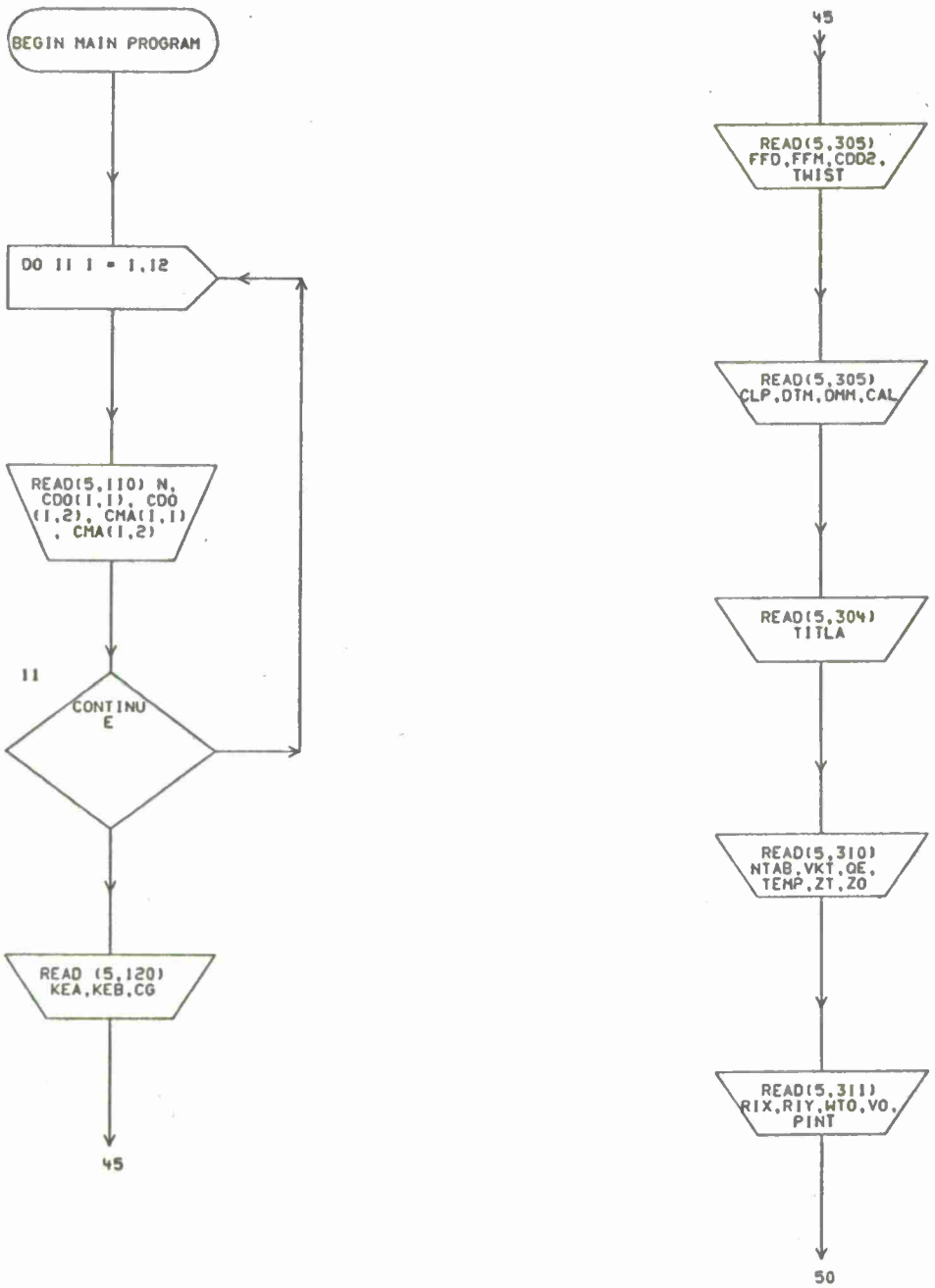
Appendix C
PROGRAM REFERENCES TO VARIABLES

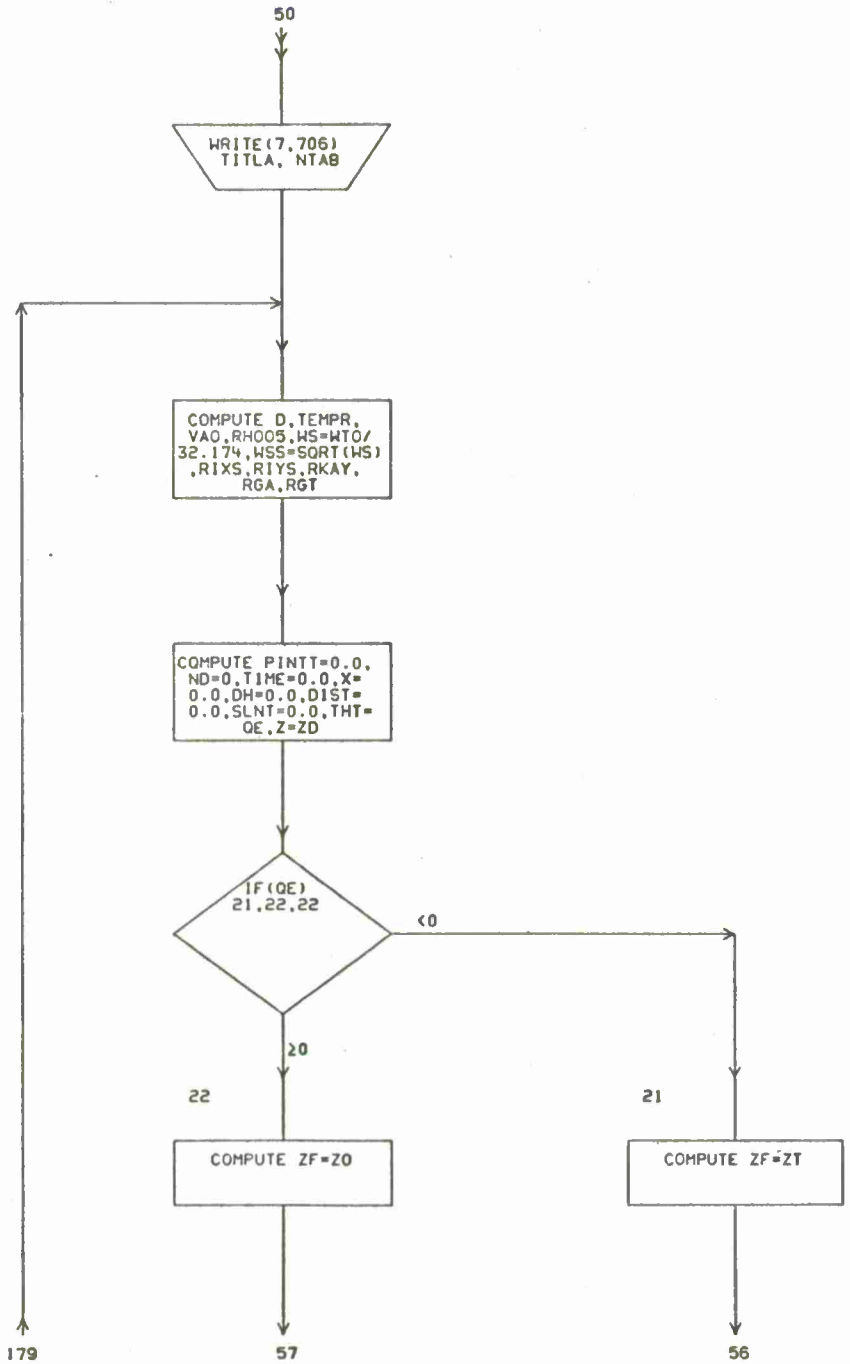
Variable	Program line number
AAC	116, 146, 148
ACCT	147, 148, 160
CAL	12, 187
CD	80, 83, 88, 92, 113, 115, 160
CDD2	11, 113, 215
CDH	52, 157
CDO	3, 6, 79, 80, 82, 83, 86, 88, 231
CG	10, 206
CLP	12, 160, 218
CM	94, 97, 102, 106, 108, 110, 126
CMA	3, 6, 93, 94, 96, 97, 100, 102, 231
D	24, 32, 48, 54
DH	39, 126, 130, 157
DIFF	86, 87, 88, 100, 101, 102
DIST	40, 151
DMM	12, 24, 185
DRAG	115, 116, 128, 146, 147, 160
DS	149, 151, 155, 156, 168, 169, 170
DT	118, 146, 148, 149, 152, 154, 159, 160
DTM	12, 118
ENG	117, 126, 130
FFD	11, 92
FFM	11, 106
GACC	114, 116, 147
GNU	55, 56, 108, 110, 160, 162
JRUN	270, 272
KEA	10, 212
KEB	10, 212

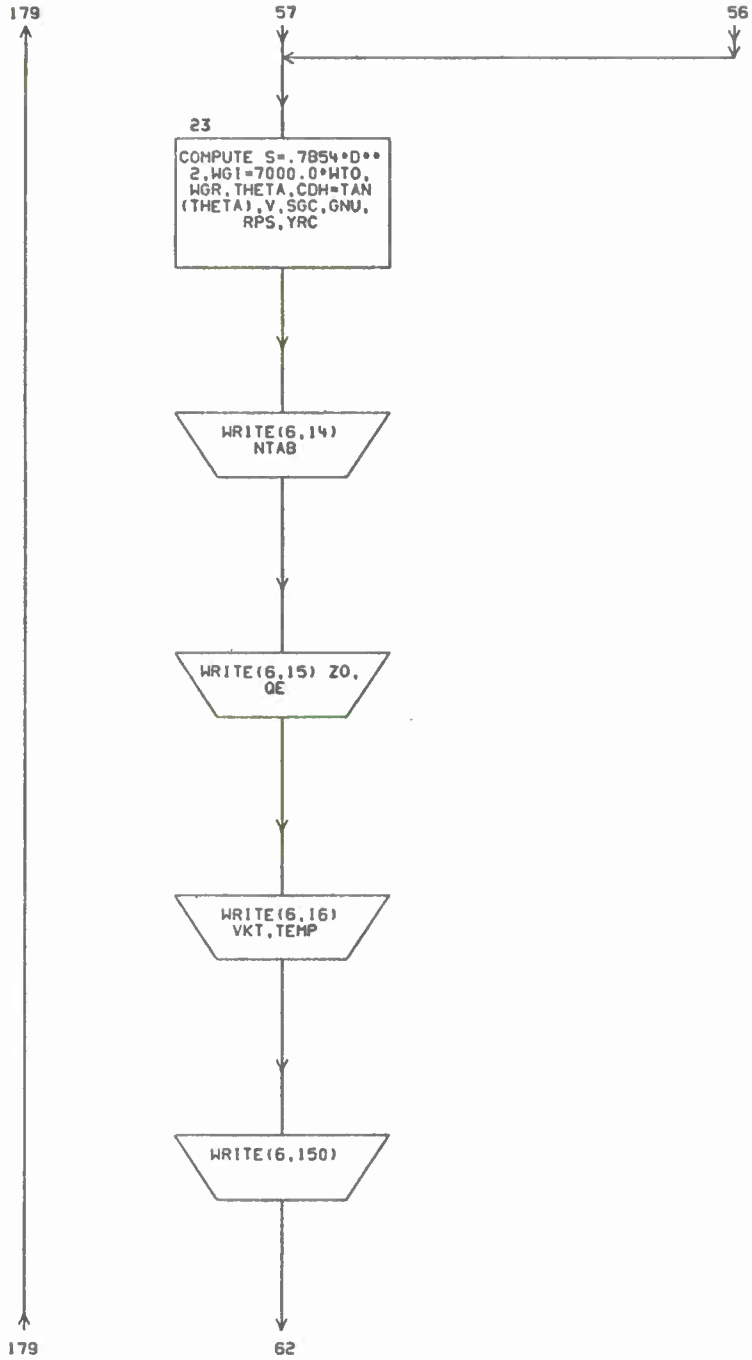
Variable	Program line number
N	6
ND	36, 133, 134, 139
NTAB	16, 19, 59, 135, 179, 221, 275, 277
PINT	18, 140, 144, 276
PINTT	35, 124, 125, 140, 144
QE	16, 42, 44, 51, 60, 137, 222, 275
RGA	33, 54, 57, 160, 201
RGT	34, 54, 203
RHO	72, 74, 108, 110, 115
RHO05	27, 54, 57, 115
RIX	18, 30, 195, 276
RIXS	30, 33
RIY	18, 31, 198, 276
RIYS	31, 34
RKAY	32, 33, 34
RPS	56, 128, 130, 162, 176
S	48, 54, 57, 115
SG	108, 128, 130, 176
SGC	54, 108
SLNT	41, 126, 130, 158, 171, 176
TEMP	16, 25, 61, 138, 223, 275
TEMPR	25, 26, 27
THBAR	154, 155, 156, 159
THETA	51, 52, 110, 114, 120, 121, 153, 154, 159, 168, 170, 172, 176
THT	42, 121, 153
TIME	37, 126, 130, 152, 166, 169, 176
TITLA	2, 13, 19, 274, 277
TTT	120, 128, 130
TWIST	11, 55, 210

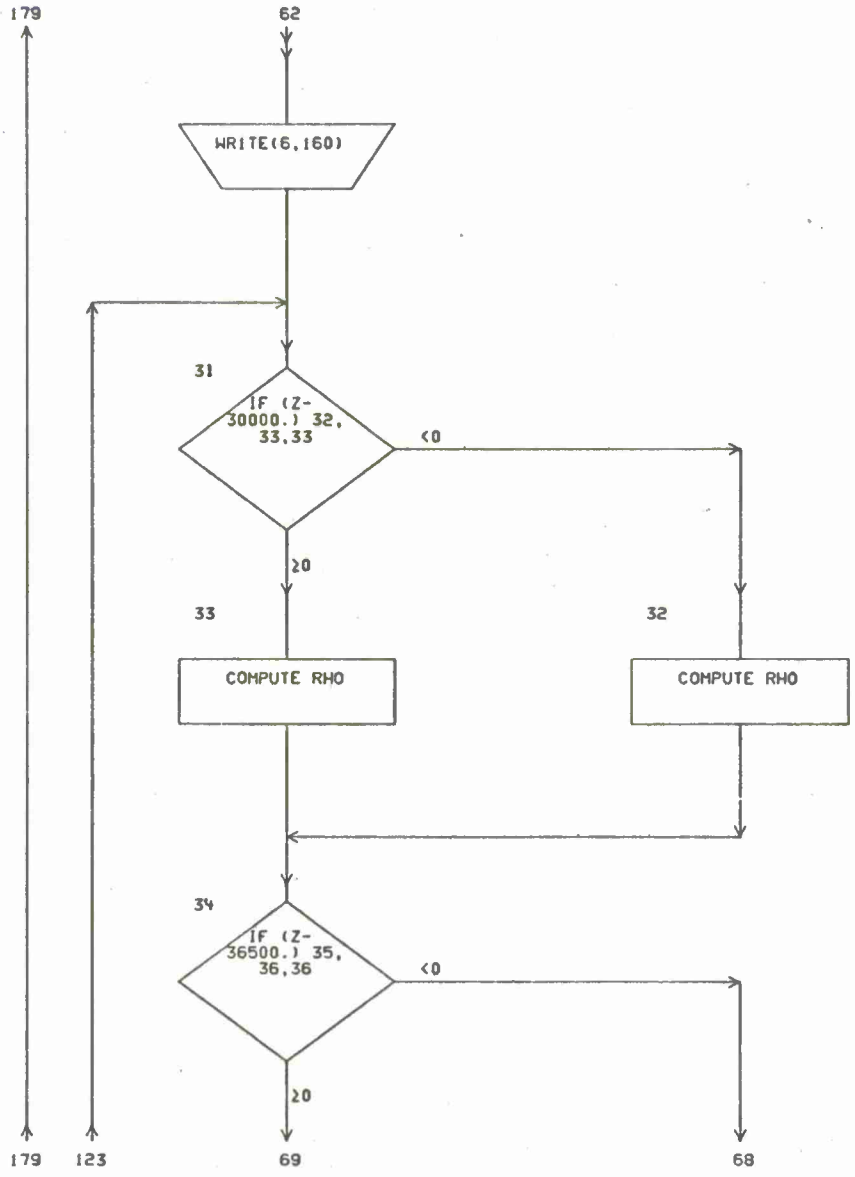
Variable	Program line number
V	53, 55, 56, 76, 78, 110, 115, 117, 126, 130, 146, 148, 150, 160, 162, 169, 176
VAO	26, 76
VBAR	148, 149, 150, 154, 159
VKT	16, 53, 61, 138, 223, 275
VM	76, 78, 79, 82, 86, 93, 96, 100, 128
VO	18, 53, 55, 208, 276
WGI	49, 190
WGR	50, 191
WS	28, 29, 108, 110, 116, 117, 147, 160
WSS	29, 32
WTO	18, 28, 49, 50, 189, 276
X	38, 126, 130, 155, 157, 158, 170, 171
YAW	111, 128
YR	110, 111, 113
YRC	57, 110
Z	43, 71, 72, 74, 75, 76, 128, 130, 156, 157, 158, 164, 168
ZF	45, 47, 122, 164
ZO	16, 43, 47, 60, 137, 157, 158, 171, 222, 275
ZT	16, 45, 122, 168, 171, 275

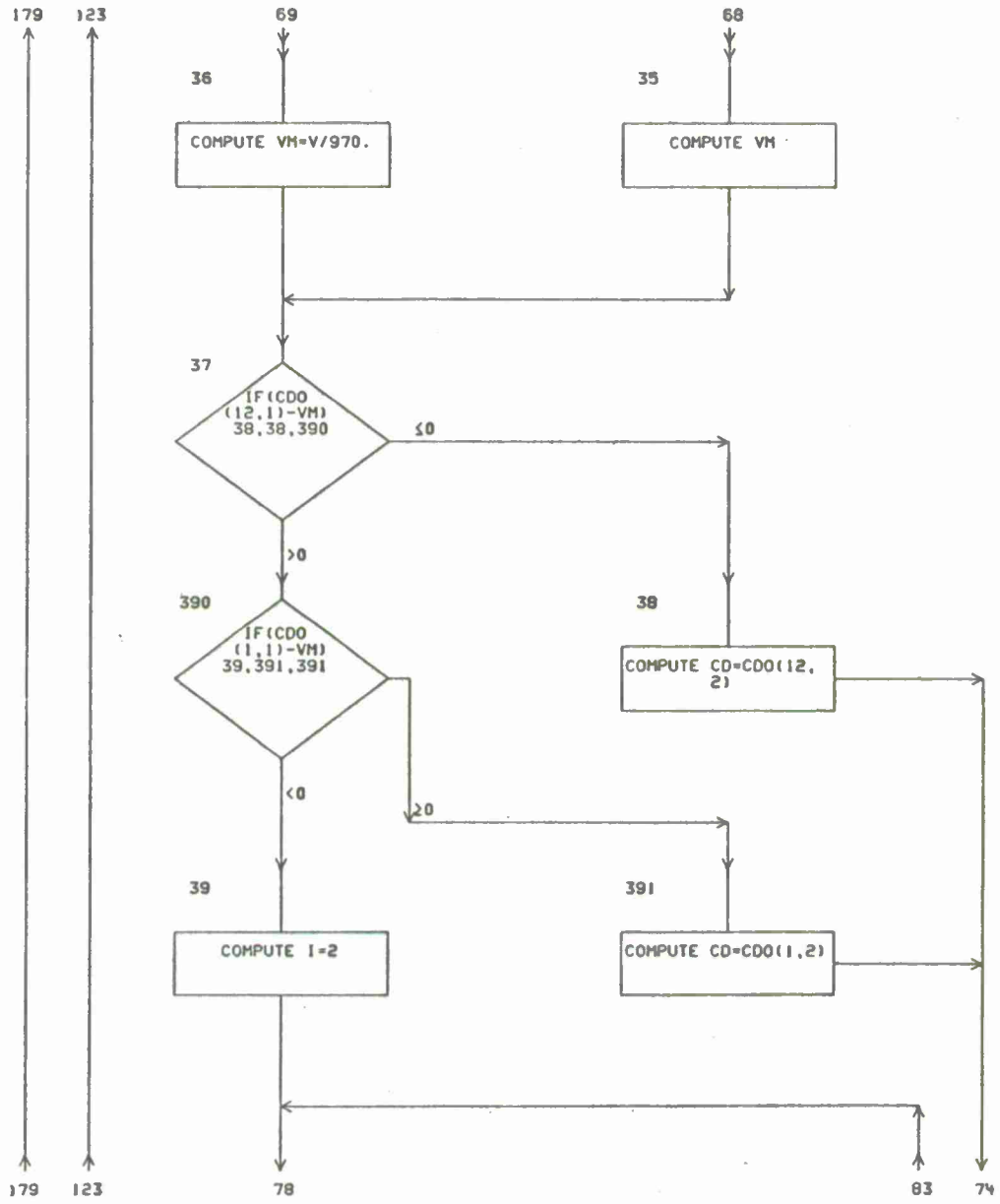
Appendix D
PROGRAM FLOW CHART

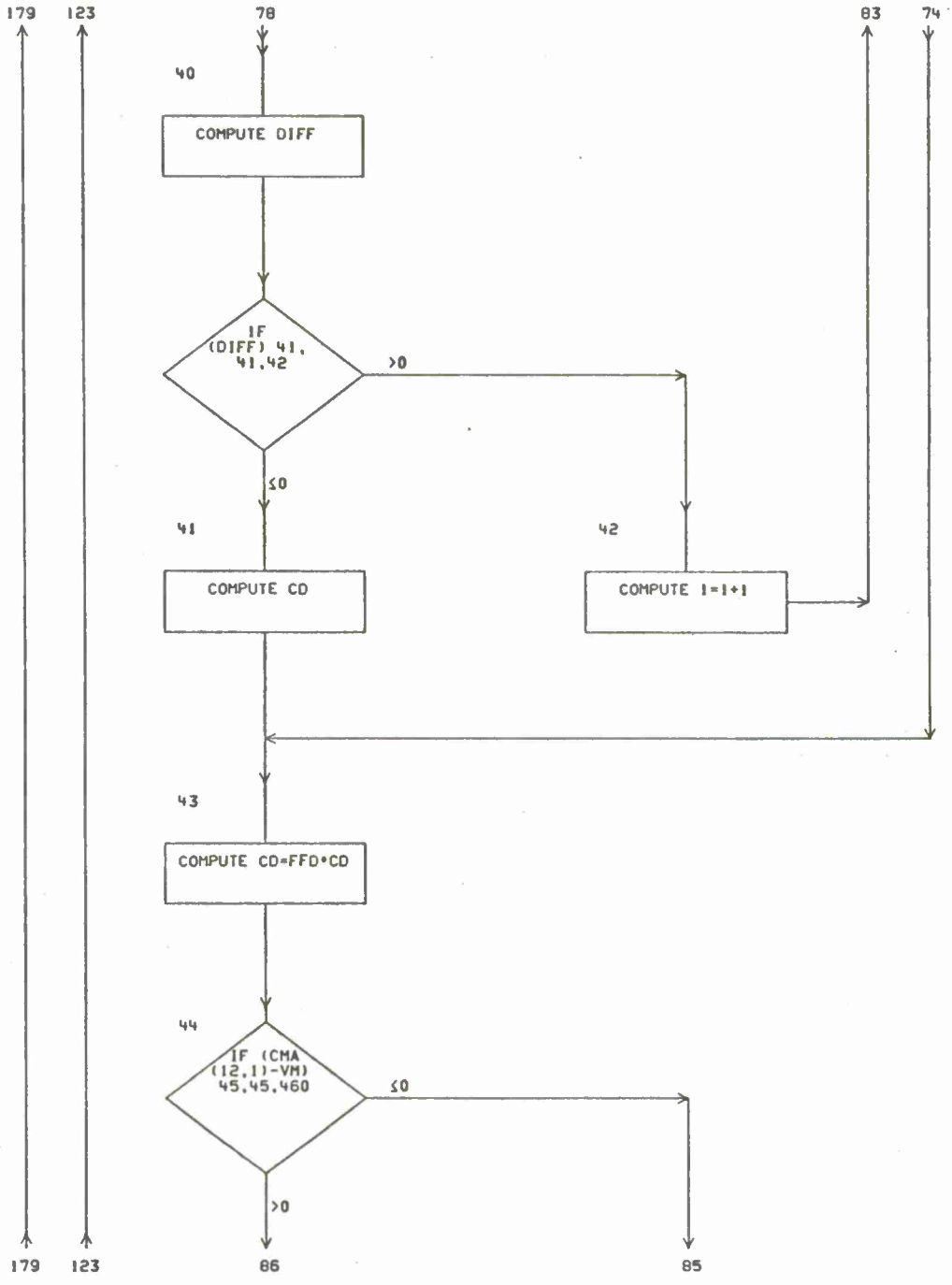


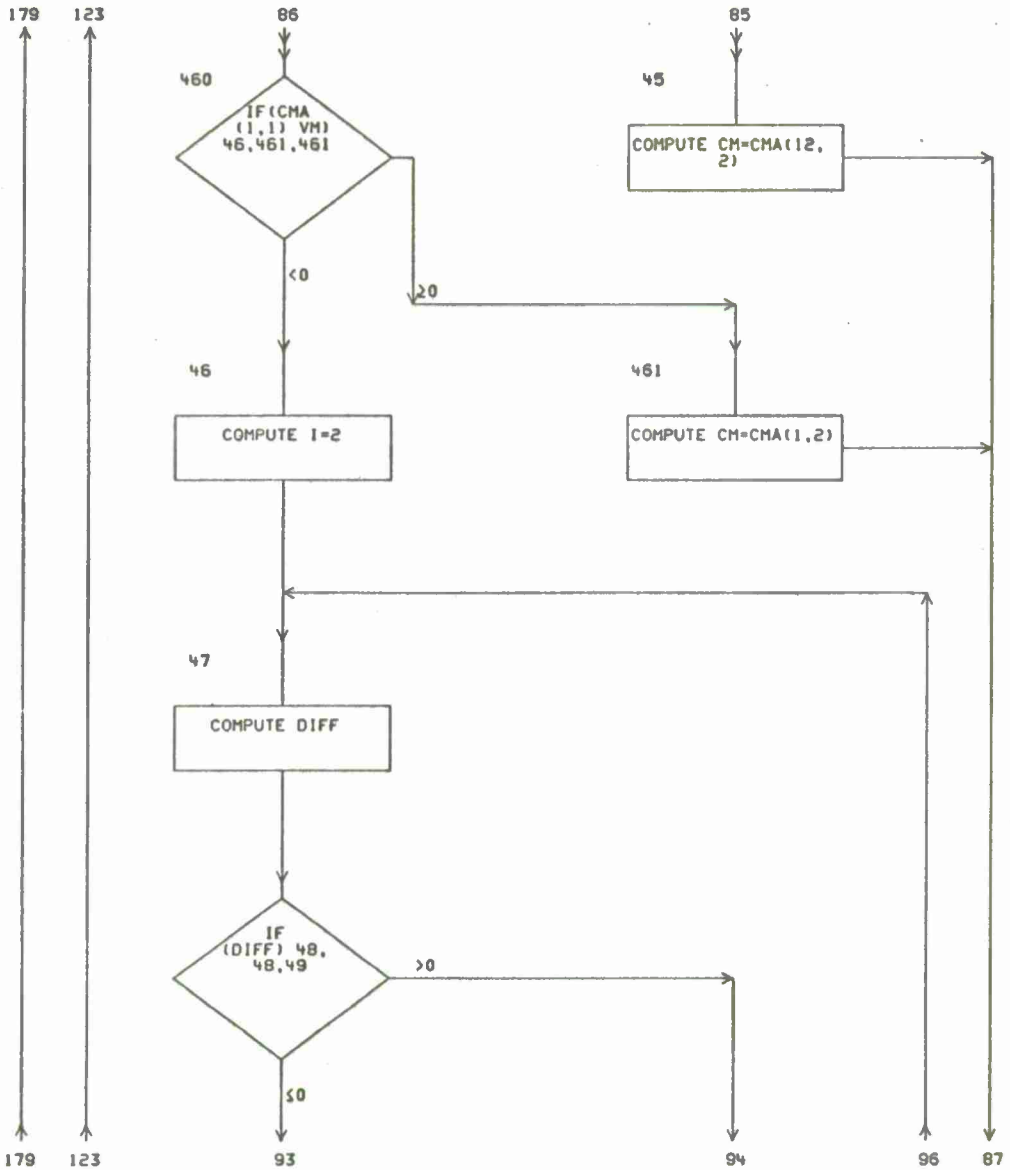

50
WRITE(7,706)
TITLA, NTAB
COMPUTE D,TEMPR,
VAO,RHO05,WS=WTO/
32.174,WSS=SQRT(WS)
,RIXS,RIYS,RKAY,
RGA,RGT
COMPUTE PINTT=0.0,
ND=0,TIME=0.0,X=
0.0,DH=0.0,DIST=
0.0,SLNT=0.0,THT=
QE,Z=ZD
IF(QE)
21,22,22
<0
≥0
22
21
COMPUTE ZF=ZO
COMPUTE ZF=ZT
179
57
56

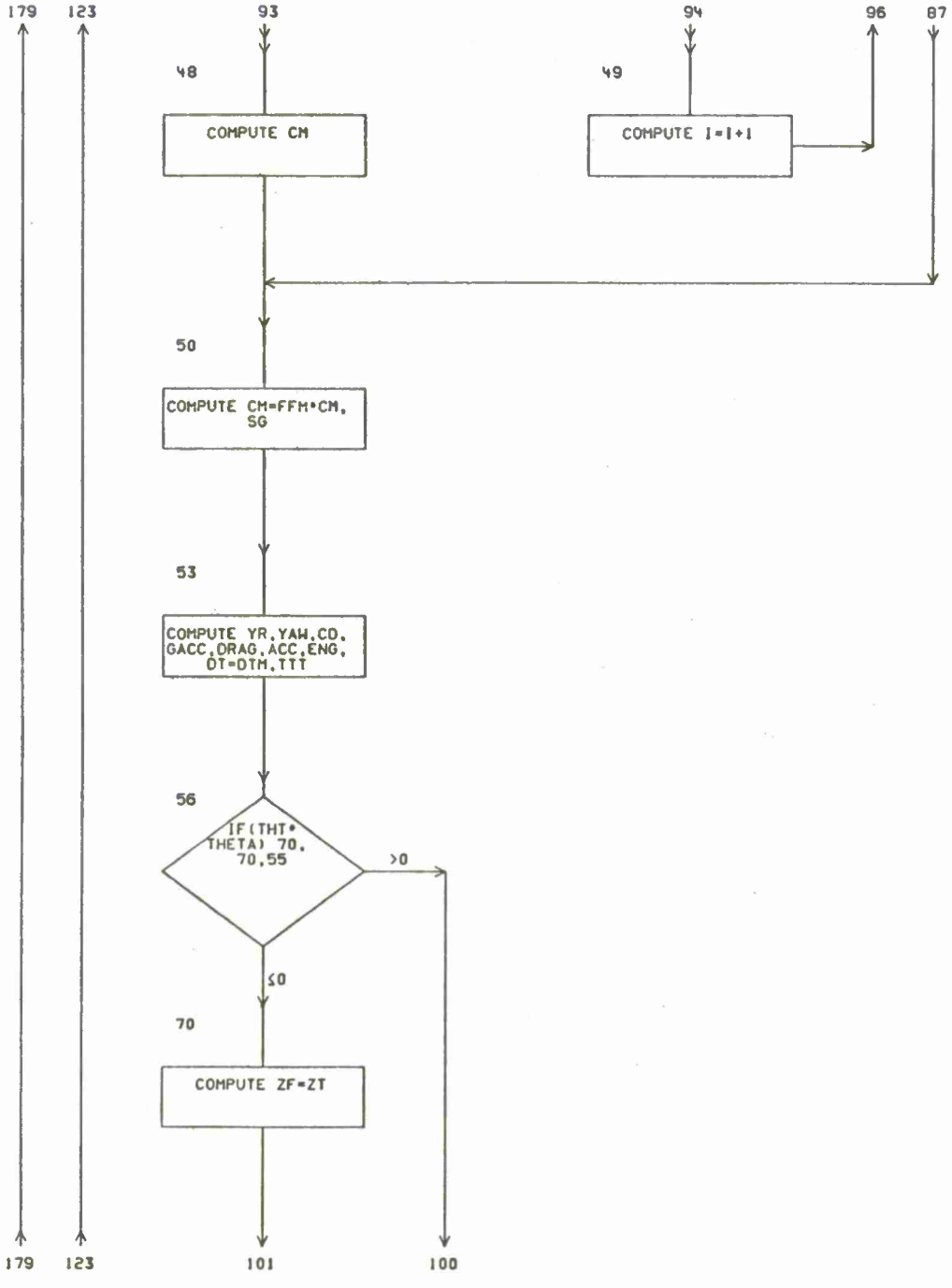

179
57
56
23
COMPUTE S=.7854*D**2,WGI=7000.0*WTO,WGR,THETA,CDH=TAN(THETA),V,SGC,GNU,RPS,YRC
WRITE(6,14) NTAB
WRITE(6,15) ZO, QE
WRITE(6,16) VKT,TEMP
WRITE(6,150)
179
62

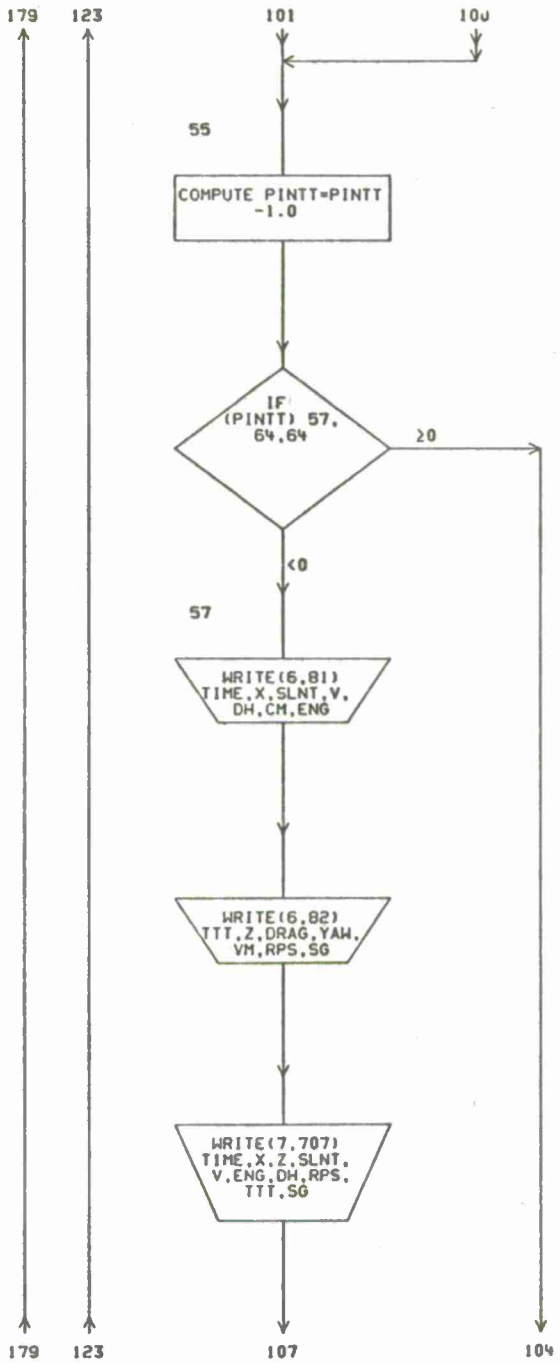

179
62
WRITE(6,160)
31
IF (Z-
30000.) 32,
33,33
<0
≥0
33
32
COMPUTE RHO
COMPUTE RHO
34
IF (Z-
36500.) 35,
36,36
<0
≥0
179
123
69
68

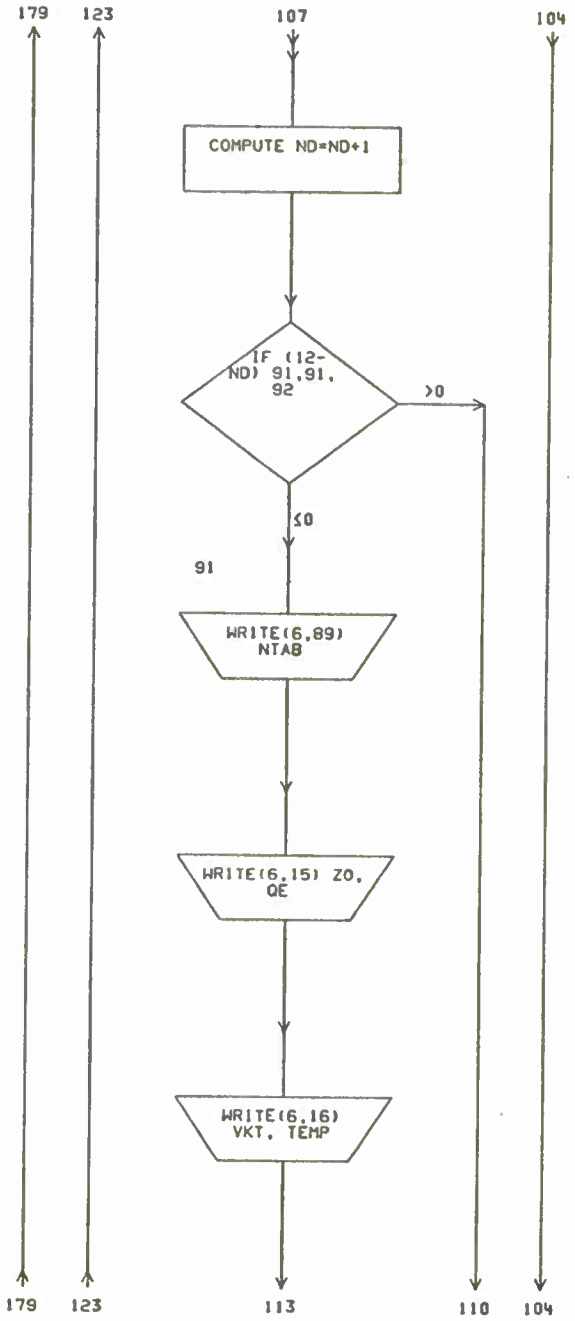

179
123
69
68
36
35
COMPUTE VM=V/970.
COMPUTE VM
37
IF(CDO
(12,1)-VM)
38,38,390
≤0
>0
390
38
IF(CDO
(1,1)-VM)
39,391,391
COMPUTE CD=CDO(12,
2)
<0
≥0
39
391
COMPUTE I=2
COMPUTE CD=CDO(1,2)
179
123
78
83
74

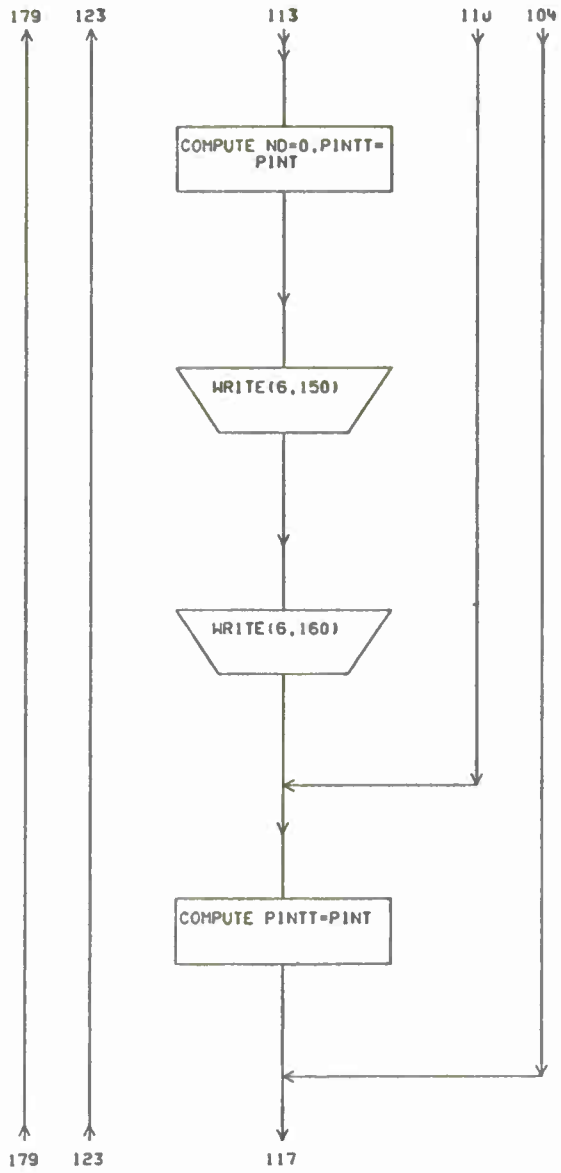

179
123
78
83
74
40
COMPUTE DIFF
IF (DIFF) 41, 41,42
>0
≤0
41
42
COMPUTE CD
COMPUTE I=I+1
43
COMPUTE CD=FFD*CD
44
IF (CMA (12,1)-VM) 45,45,460
≤0
>0
179
123
86
85

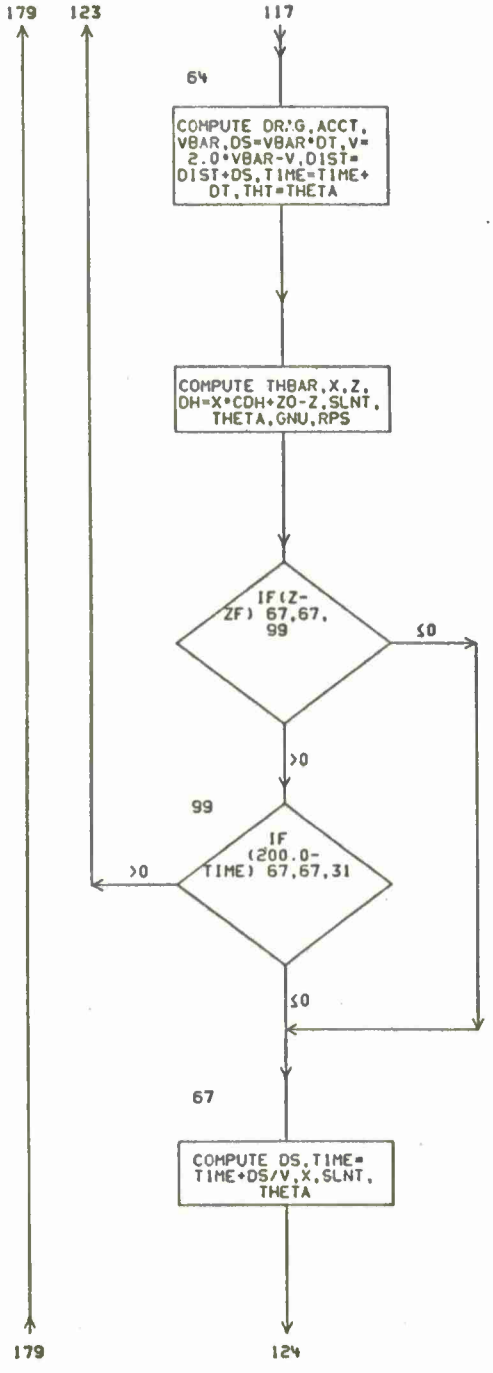

179
123
86
460
IF(CMA (1,1) VM) 46,461,461
<0
≥0
46
COMPUTE I=2
85
45
COMPUTE CM=CMA(12, 2)
461
COMPUTE CM=CMA(1,2)
47
COMPUTE DIFF
IF (DIFF) 48, 48,49
>0
≤0
179
123
93
94
96
87

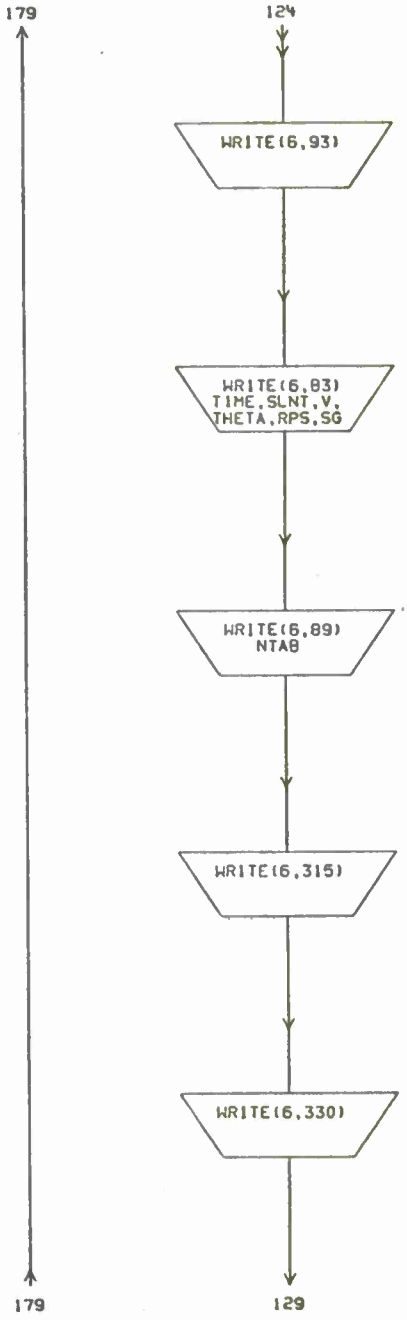

179
123
93
94
96
87
48
49
COMPUTE CM
COMPUTE I=I+1
50
COMPUTE CM=FFM*CM, SG
53
COMPUTE YR,YAW,CD, GACC,DRAG,ACC,ENG, DT=DTM,TTT
56
IF(THT* THETA) 70, 70,55
>0
≤0
70
COMPUTE ZF=ZT
179
123
101
100

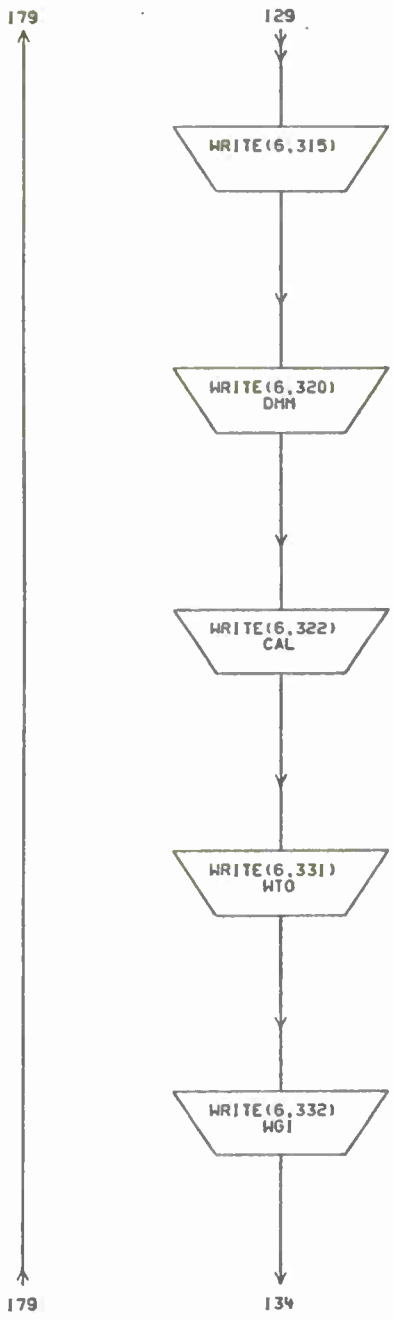

179
123
101
100
55
COMPUTE PINTT=PINTT -1.0
IF (PINTT) 57, 64,64
≥0
<0
57
WRITE(6,81) TIME,X,SLNT,V, DH,CM,ENG
WRITE(6,82) TTT,Z,DRAG,YAW, VM,RPS,SG
WRITE(7,707) TIME,X,Z,SLNT, V,ENG,DH,RPS, TTT,SG
179
123
107
104

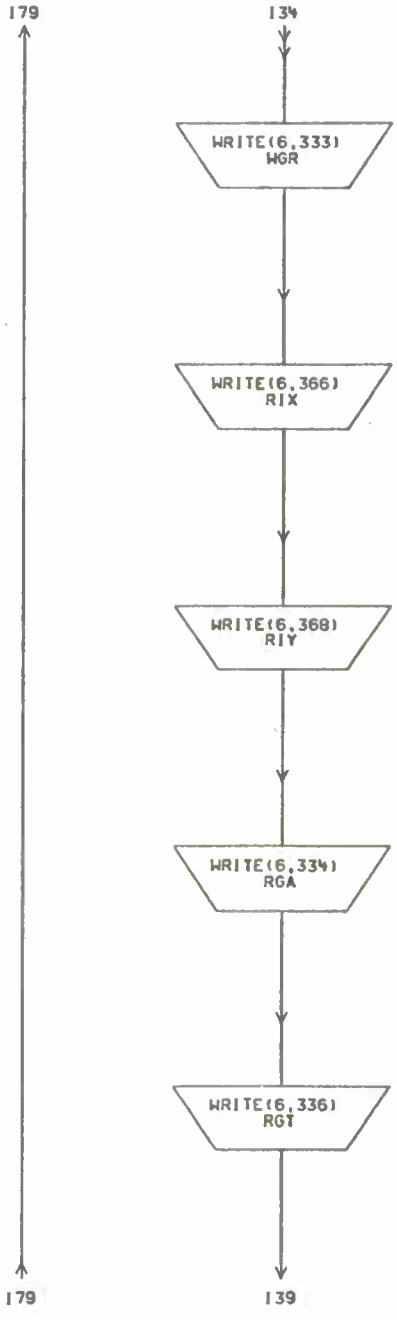

179
123
107
104
COMPUTE ND=ND+1
IF (12-ND) 91,91, 92
>0
≤0
91
WRITE(6,89) NTAB
WRITE(6,15) Z0, QE
WRITE(6,16) VKT, TEMP
179
123
113
110
104

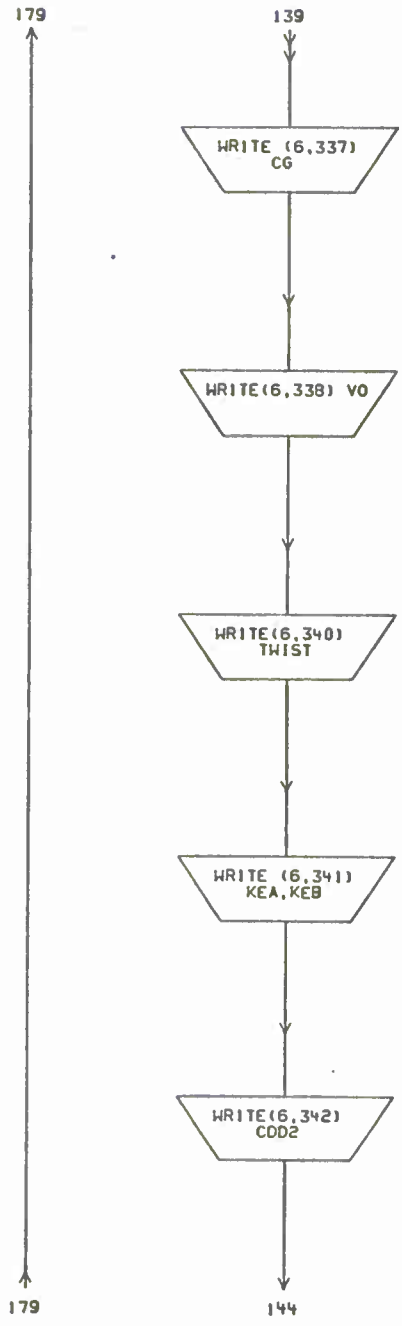

179
123
113
110
104
COMPUTE ND=0,PINTT=PINT
WRITE(6,150)
WRITE(6,160)
COMPUTE PINTT=PINT
179
123
117

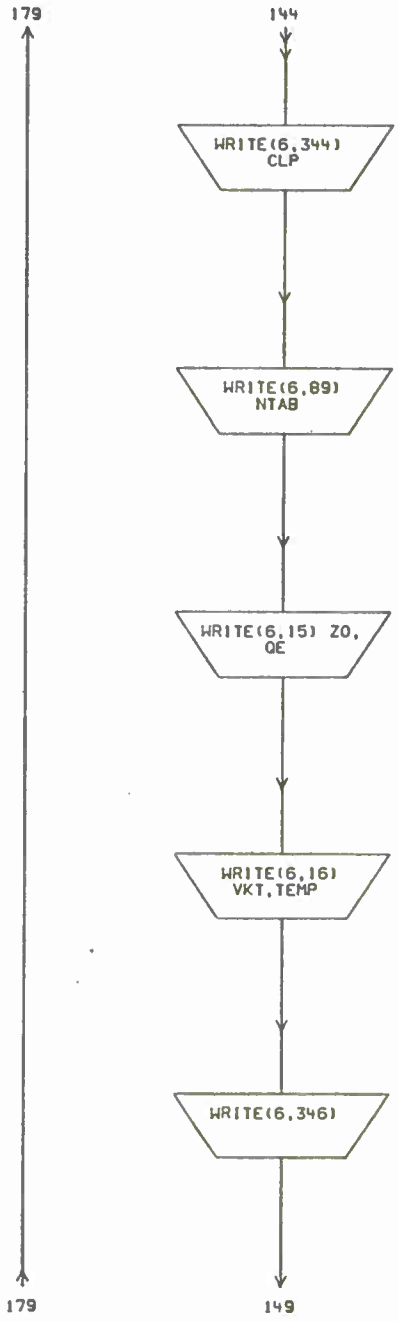

179
123
117
64
COMPUTE DRAG,ACCT, VBAR,DS=VBAR*DT,V= 2.0*VBAR-V,DIST= DIST+DS,TIME=TIME+ DT,THT=THETA
COMPUTE THBAR,X,Z, DH=X*CDH+ZO-Z,SLNT, THETA,GNU,RPS
IF(Z-ZF) 67,67, 99
≤0
>0
99
IF (200.0-TIME) 67,67,31
>0
≤0
67
COMPUTE DS,TIME= TIME+DS/V,X,SLNT, THETA
179
124

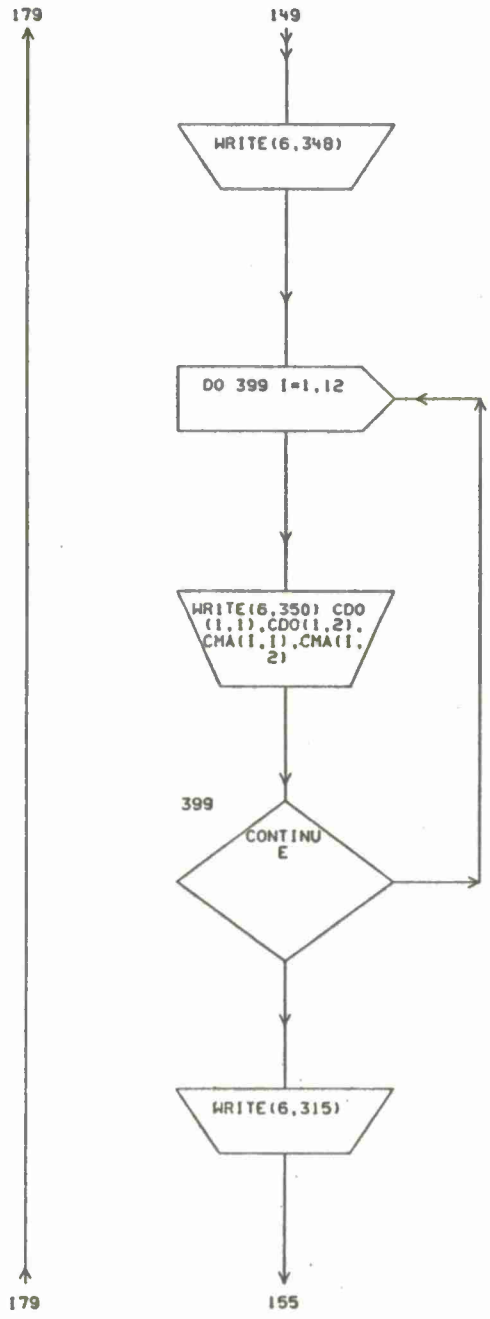

179
124
WRITE(6,93)
WRITE(6,83) TIME,SLNT,V, THETA,RPS,SG
WRITE(6,89) NTAB
WRITE(6,315)
WRITE(6,330)
179
129

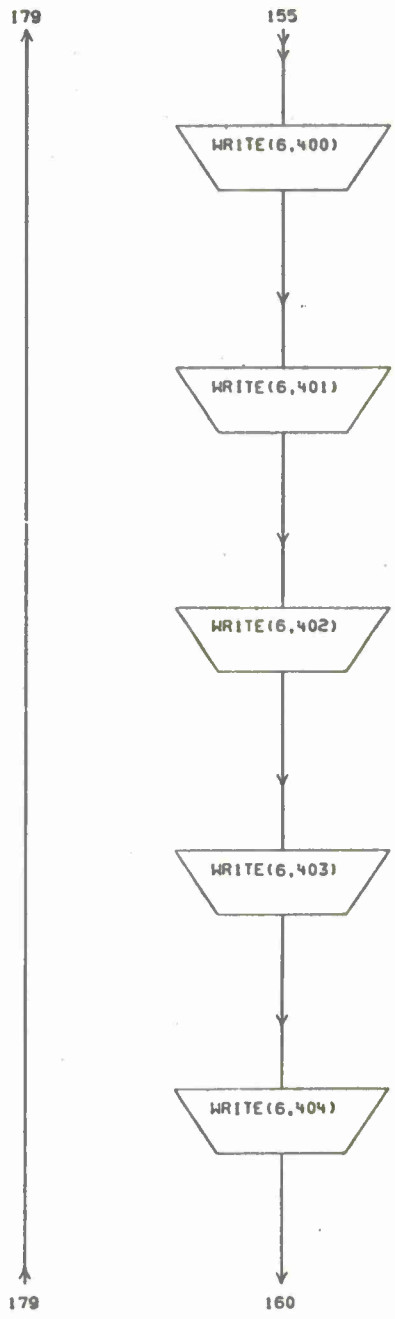

179
129
WRITE(6,315)
WRITE(6,320)
DMM
WRITE(6,322)
CAL
WRITE(6,331)
WTO
WRITE(6,332)
WGI
179
134

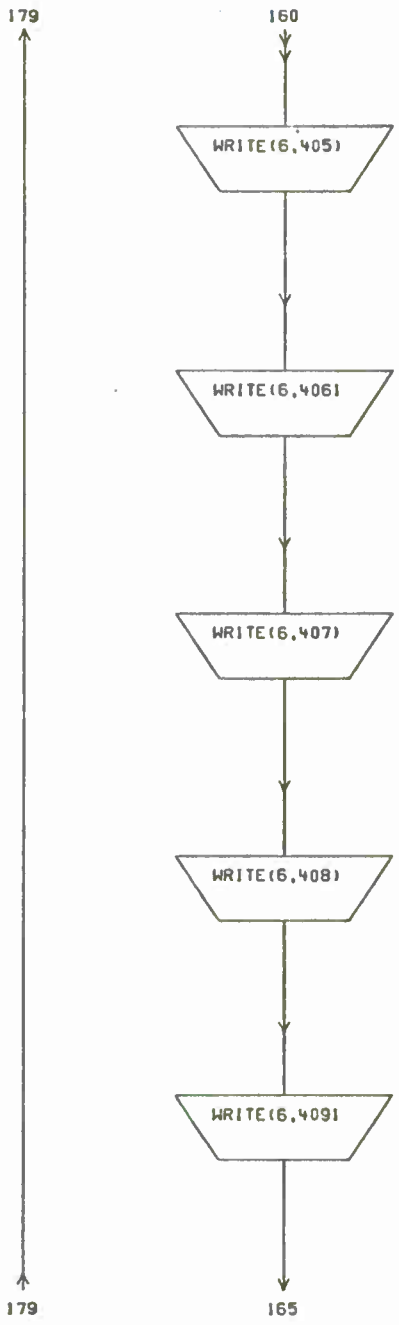

179
134
WRITE(6,333)
WGR
WRITE(6,366)
RIX
WRITE(6,368)
RIY
WRITE(6,334)
RGA
WRITE(6,336)
RGT
179
139

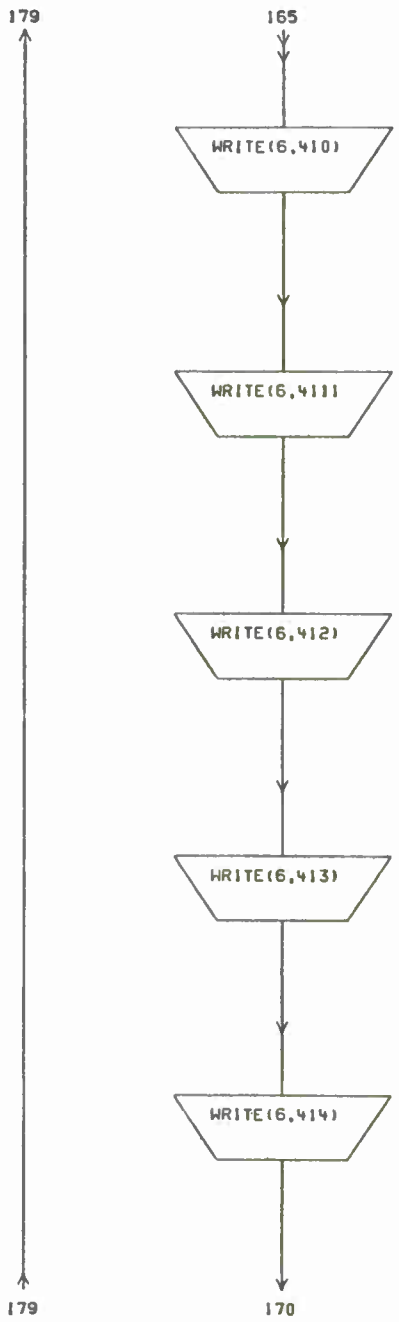

179
139
WRITE (6,337)
CG
WRITE(6,338) VO
WRITE(6,340)
TWIST
WRITE (6,341)
KEA,KEB
WRITE(6,342)
CDD2
179
144

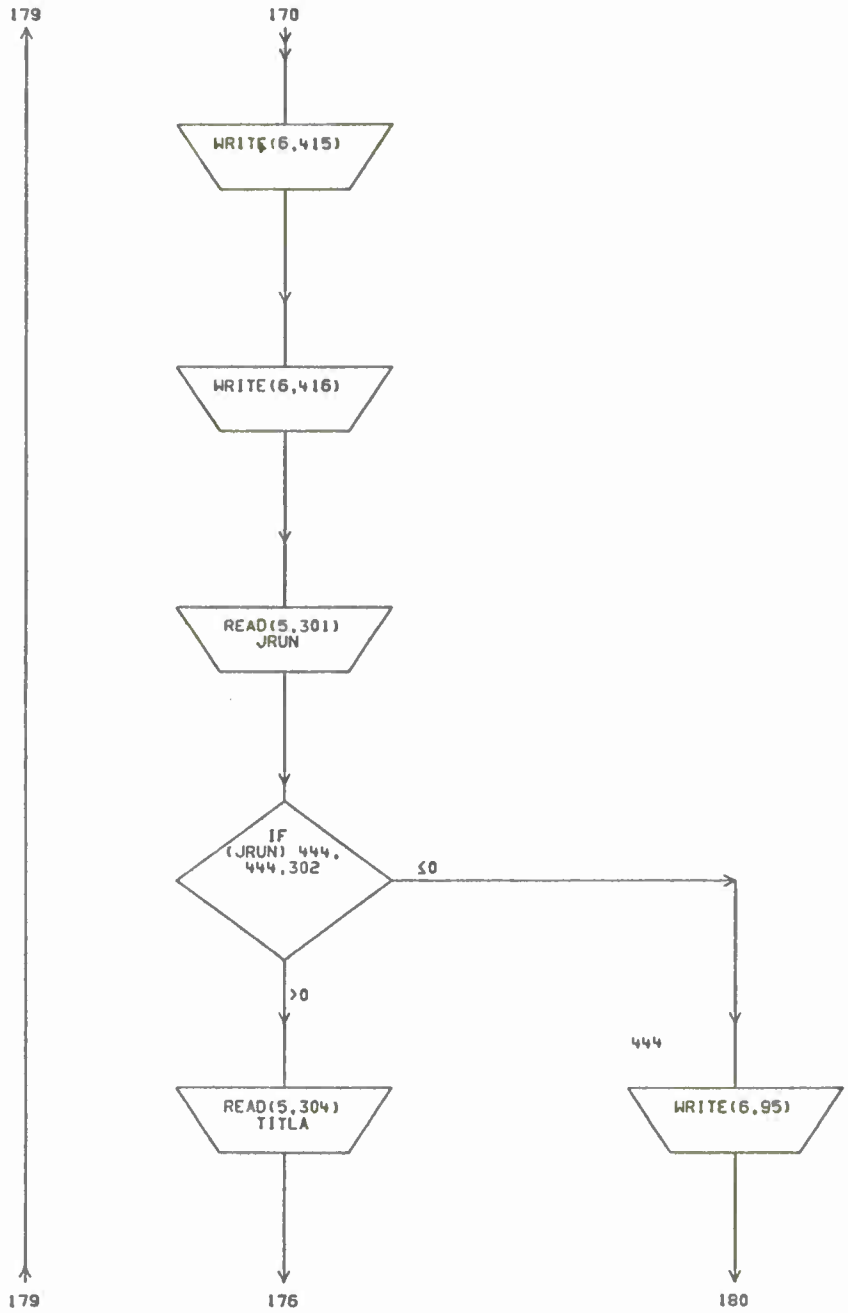

179
144
WRITE(6,344)
CLP
WRITE(6,89)
NTAB
WRITE(6,15) ZO,
QE
WRITE(6,16)
VKT,TEMP
WRITE(6,346)
179
149

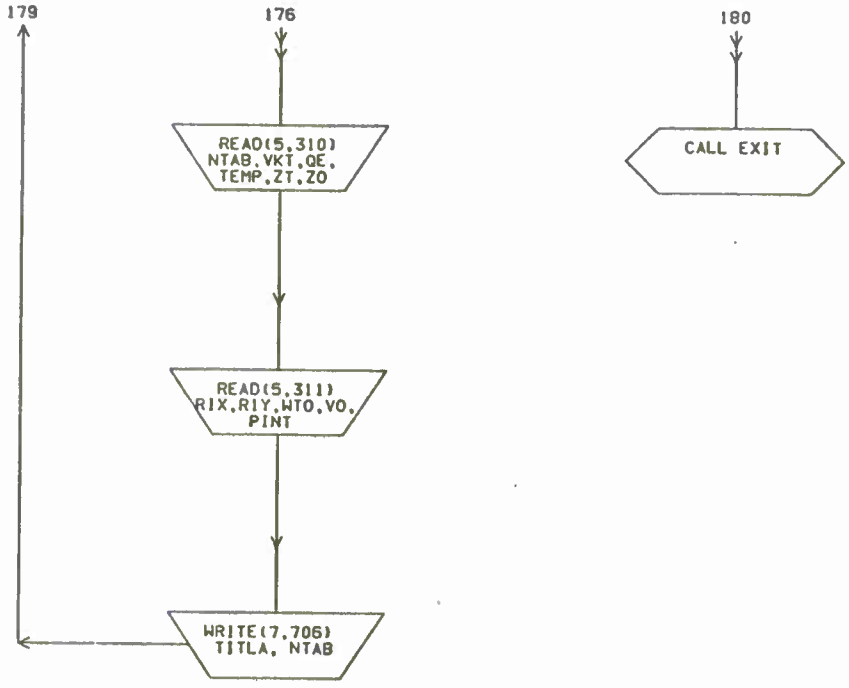

179
149
WRITE(6,348)
DO 399 I=1,12
WRITE(6,350) CDO
(I,1),CDO(I,2),
CMA(I,1),CMA(I,
2)
399
CONTINU
E
WRITE(6,315)
179
155


179
155
WRITE(6,400)
WRITE(6,401)
WRITE(6,402)
WRITE(6,403)
WRITE(6,404)
179
160


179
160
WRITE(6,405)
WRITE(6,406)
WRITE(6,407)
WRITE(6,408)
WRITE(6,409)
179
165


179
165
WRITE(6,410)
WRITE(6,411)
WRITE(6,412)
WRITE(6,413)
WRITE(6,414)
179
170


179
170
WRITE(6,415)
WRITE(6,416)
READ(5,301)
JRUN
IF
(JRUN) 444,
444,302
≤0
>0
444
READ(5,304)
TITLA
WRITE(6,95)
179
176
180


179
176
180
READ(5,310) NTAB,VKT,QE, TEMP,ZT,ZO
READ(5,311) RIX,RIY,WTO,VO, PINT
WRITE(7,706) TITLA, NTAB
CALL EXIT

Appendix E
TYPICAL TRAJECTORY TABLE OUTPUT

This represents a typical trajectory table for the 20-mm M56 projectile, fired at +15 degrees elevation.

TRAJECTORY TABLE NUMBER 1

ALTITUDE: .0 FEET GE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME THETA	X Z	DIST DRAG	V YAW	DH MACH	CMA SPIN	ENG SG
.00	0.	0.	3360.0	.0	1.89	39099.
15.00	0.	17.831	.0048	3.01	2016.	3.87
.10	313.	324.	3121.5	.2	1.95	33746.
14.95	84.	15.782	.0057	2.80	1980.	4.20
.20	604.	626.	2909.5	.6	2.01	29318.
14.89	161.	14.023	.0068	2.61	1946.	4.55
.30	877.	907.	2720.4	1.4	2.07	25631.
14.82	234.	12.565	.0080	2.44	1916.	4.91
.40	1131.	1171.	2550.3	2.4	2.14	22526.
14.76	301.	11.379	.0092	2.29	1889.	5.25
.50	1371.	1418.	2395.9	3.6	2.21	19880.
14.68	364.	10.358	.0107	2.15	1863.	5.62
.60	1596.	1651.	2254.9	5.1	2.27	17610.
14.61	422.	9.429	.0123	2.02	1839.	6.02
.70	1808.	1870.	2126.2	6.8	2.34	15657.
14.52	477.	8.578	.0141	1.91	1817.	6.44
.80	2008.	2076.	2008.9	8.8	2.40	13976.
14.44	529.	7.812	.0162	1.80	1796.	6.88
.90	2197.	2272.	1901.7	10.9	2.46	12524.
14.35	578.	7.126	.0184	1.71	1777.	7.36
1.00	2377.	2457.	1803.6	13.3	2.51	11266.
14.25	624.	6.524	.0210	1.62	1759.	7.85
1.10	2547.	2633.	1713.6	15.8	2.56	10169.
14.15	667.	5.983	.0238	1.54	1743.	8.36

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET QE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME THETA	X Z	DIST DRAG	V YAW	DH MACH	CMA SPIN	ENG SG
1.20 14.04	2709. 707.	2800. 5.501	1630.8 .0268	18.5 1.47	2.62 1727.	9211. 8.89
1.30 13.93	2864. 746.	2959. 5.070	1554.5 .0300	21.5 1.40	2.68 1712.	8369. 9.41
1.40 13.81	3011. 782.	3111. 4.681	1484.0 .0336	24.6 1.33	2.73 1698.	7527. 9.97
1.50 13.69	3152. 817.	3256. 4.329	1418.8 .0375	27.8 1.28	2.78 1685.	6972. 10.56
1.60 13.56	3287. 850.	3395. 4.010	1358.3 .0418	31.3 1.22	2.83 1673.	6390. 11.17
1.70 13.43	3417. 881.	3528. 3.682	1302.2 .0463	34.9 1.17	2.89 1661.	5873. 11.76
1.80 13.28	3541. 910.	3656. 3.367	1250.5 .0509	38.7 1.12	2.95 1650.	5416. 12.34
1.90 13.14	3660. 938.	3779. 2.911	1203.1 .0559	42.7 1.08	3.00 1640.	5013. 12.94
2.00 12.99	3775. 965.	3897. 2.533	1161.8 .0608	46.8 1.04	3.05 1630.	4675. 13.50
2.10 12.83	3887. 990.	4011. 2.228	1125.7 .0657	51.1 1.01	3.09 1621.	4388. 14.04
2.20 12.67	3995. 1015.	4122. 1.910	1093.7 .0700	55.6 .98	3.15 1612.	4143. 14.45
2.30 12.50	4101. 1038.	4230. 1.615	1066.2 .0747	60.3 .96	3.18 1604.	3937. 14.97

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET QE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME THETA	X Z	DIST DRAG	V YAW	DH MACH	CMA SPIN	ENG SG
2.40 12.33	4204. 1061.	4335. 1.381	1042.7 .0803	65.3 .94	3.15 1597.	3765. 15.65
2.50 12.16	4304. 1083.	4439. 1.193	1022.4 .0855	70.4 .92	3.13 1590.	3621. 16.26
2.60 11.98	4404. 1104.	4540. 1.039	1004.8 .0904	75.8 .90	3.11 1583.	3497. 16.81
2.70 11.80	4501. 1125.	4640. .962	989.4 .0950	81.4 .89	3.09 1576.	3390. 17.30
2.80 11.61	4597. 1145.	4738. .912	975.1 .0995	87.2 .88	3.07 1569.	3293. 17.77
2.90 11.43	4692. 1164.	4834. .865	961.4 .1040	93.3 .87	3.05 1563.	3201. 18.23
3.00 11.24	4786. 1183.	4930. .823	948.5 .1086	99.6 .85	3.04 1557.	3116. 18.69
3.10 11.05	4878. 1201.	5024. .783	936.1 .1132	106.2 .84	3.03 1551.	3035. 19.13
3.20 10.85	4970. 1219.	5117. .747	924.4 .1178	113.0 .83	3.01 1544.	2959. 19.57
3.30 10.65	5060. 1236.	5209. .713	913.1 .1224	120.1 .82	3.00 1539.	2888. 20.00
3.40 10.45	5149. 1252.	5299. .682	902.3 .1270	127.3 .81	2.99 1533.	2820. 20.42
3.50 10.25	5237. 1268.	5389. .653	892.0 .1317	134.9 .80	2.97 1527.	2756. 20.83

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET QE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME THETA	X Z	DIST DRAG	V YAW	DH MACH	CMA SPIN	ENG SG
3.60 10.05	5325. 1284.	5477. .634	882.1 .1360	142.6 .79	2.97 1521.	2695. 21.18
3.70 9.84	5411. 1299.	5565. .620	872.5 .1402	150.6 .79	2.97 1516.	2637. 21.51
3.80 9.63	5497. 1314.	5652. .606	863.1 .1444	158.9 .78	2.97 1510.	2580. 21.83
3.90 9.42	5581. 1328.	5737. .593	853.9 .1488	167.4 .77	2.97 1505.	2525. 22.15
4.00 9.21	5665. 1342.	5822. .580	844.9 .1532	176.1 .76	2.97 1500.	2473. 22.48
4.10 8.99	5748. 1355.	5906. .568	836.1 .1577	185.0 .75	2.97 1494.	2421. 22.80
4.20 8.77	5830. 1368.	5989. .556	827.5 .1623	194.2 .75	2.97 1489.	2372. 23.13
4.30 8.55	5912. 1380.	6071. .545	819.1 .1669	203.6 .74	2.97 1484.	2323. 23.45
4.40 8.32	5992. 1392.	6152. .534	810.8 .1717	213.3 .73	2.97 1479.	2277. 23.78
4.50 8.10	6072. 1404.	6232. .523	802.7 .1765	223.1 .72	2.97 1474.	2232. 24.11
4.60 7.87	6151. 1415.	6312. .512	794.8 .1814	233.2 .72	2.97 1469.	2188. 24.44
4.70 7.64	6230. 1426.	6391. .502	787.0 .1864	243.6 .71	2.97 1464.	2145. 24.77

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET QE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME	X	DIST	V	DH	CMA	ENG
THETA	Z	DRAG	YAW	MACH	SPIN	SG
4.80	6307.	6469.	779.4	254.1	2.97	2104.
7.41	1436.	.492	.1914	.70	1460.	25.10
4.90	6384.	6546.	772.0	264.9	2.97	2064.
7.17	1446.	.483	.1965	.70	1455.	25.43
5.00	6460.	6622.	764.7	275.9	2.97	2025.
6.93	1455.	.474	.2018	.69	1450.	25.76
5.10	6536.	6698.	757.5	287.1	2.97	1987.
6.69	1464.	.465	.2070	.68	1446.	26.10
5.20	6611.	6773.	750.5	298.6	2.97	1951.
6.45	1473.	.456	.2124	.68	1441.	26.43
5.30	6685.	6847.	743.6	310.2	2.97	1915.
6.20	1481.	.448	.2178	.67	1437.	26.76
5.40	6759.	6921.	736.9	322.1	2.97	1880.
5.96	1489.	.439	.2234	.66	1432.	27.09
5.50	6832.	6994.	730.2	334.2	2.97	1847.
5.71	1496.	.431	.2289	.66	1428.	27.43
5.60	6904.	7066.	723.7	346.5	2.97	1814.
5.45	1503.	.424	.2346	.65	1424.	27.76
5.70	6976.	7137.	717.4	359.1	2.97	1782.
5.20	1510.	.416	.2404	.65	1420.	28.09
5.80	7047.	7208.	711.1	371.8	2.97	1751.
4.94	1516.	.409	.2462	.64	1415.	28.43
5.90	7118.	7279.	705.0	384.8	2.97	1721.
4.68	1522.	.402	.2520	.64	1411.	28.76

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET QE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME THETA	X Z	DIST DRAG	V YAW	DH MACH	CMA SPIN	ENG SG
6.00	7188.	7348.	699.0	397.9	2.97	1692.
4.42	1528.	.395	.2580	.63	1407.	29.09
6.10	7257.	7417.	693.1	411.3	2.97	1664.
4.16	1533.	.388	.2640	.62	1403.	29.43
6.20	7326.	7486.	687.3	424.9	2.97	1636.
3.89	1538.	.382	.2701	.62	1399.	29.76
6.30	7394.	7553.	681.6	438.8	2.97	1609.
3.62	1542.	.375	.2763	.61	1395.	30.09
6.40	7462.	7620.	676.0	452.8	2.97	1583.
3.35	1547.	.369	.2825	.61	1391.	30.42
6.50	7529.	7687.	670.6	467.0	2.97	1557.
3.08	1550.	.363	.2888	.60	1387.	30.75
6.60	7596.	7753.	665.2	481.5	2.97	1532.
2.80	1554.	.357	.2951	.60	1384.	31.08
6.70	7662.	7819.	659.9	496.1	2.97	1508.
2.52	1557.	.352	.3015	.59	1380.	31.41
6.80	7728.	7883.	654.7	511.0	2.97	1485.
2.24	1560.	.346	.3080	.59	1376.	31.74
6.90	7793.	7948.	649.6	526.1	2.97	1462.
1.96	1562.	.341	.3145	.59	1372.	32.07
7.00	7858.	8012.	644.6	541.3	2.97	1439.
1.68	1564.	.336	.3211	.58	1369.	32.40
7.10	7922.	8075.	639.7	556.8	2.97	1417.
1.39	1566.	.331	.3277	.58	1365.	32.73

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET QE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME THETA	X Z	DIST DRAG	V YAW	DH MACH	CMA SPIN	ENG SG
7.20	7985.	8138.	634.9	572.5	2.97	1396.
1.10	1567.	.326	.3344	.57	1362.	33.05
7.30	8049.	8200.	630.2	588.4	2.97	1375.
.81	1568.	.321	.3412	.57	1358.	33.38
7.40	8111.	8262.	625.6	604.5	2.97	1355.
.52	1569.	.316	.3479	.56	1354.	33.70
7.50	8174.	8323.	621.0	620.8	2.97	1336.
.22	1569.	.311	.3548	.56	1351.	34.02
7.60	8236.	8384.	616.5	637.3	2.97	1316.
-.08	1569.	.307	.3616	.56	1348.	34.34
7.70	8297.	8444.	612.1	654.0	2.97	1298.
-.38	1569.	.303	.3685	.55	1344.	34.66
7.80	8358.	8504.	607.8	670.9	2.97	1279.
-.68	1569.	.298	.3755	.55	1341.	34.98
7.90	8419.	8563.	603.6	688.0	2.97	1262.
-.98	1568.	.294	.3824	.54	1337.	35.30
8.00	8479.	8622.	599.4	705.3	2.97	1244.
-1.29	1567.	.290	.3894	.54	1334.	35.61
8.10	8539.	8681.	595.3	722.8	2.97	1227.
-1.60	1565.	.286	.3965	.54	1331.	35.92
8.20	8598.	8739.	591.3	740.5	2.97	1211.
-1.91	1563.	.283	.4035	.53	1328.	36.23
8.30	8657.	8796.	587.4	758.5	2.97	1195.
-2.22	1561.	.279	.4106	.53	1324.	36.54

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET QE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME	X	DIST	V	DH	CMA	ENG
THETA	Z	DRAG	YAW	MACH	SPIN	SG
8.40	8715.	8853.	583.5	776.6	2.97	1179.
-2.54	1559.	.275	.4177	.53	1321.	36.85
8.50	8773.	8910.	579.7	794.9	2.97	1164.
-2.85	1556.	.272	.4248	.52	1318.	37.15
8.60	8831.	8966.	575.9	813.4	2.97	1149.
-3.17	1553.	.268	.4320	.52	1315.	37.45
8.70	8888.	9022.	572.3	832.0	2.97	1134.
-3.49	1550.	.265	.4391	.52	1312.	37.75
8.80	8945.	9078.	568.7	850.9	2.97	1120.
-3.82	1546.	.262	.4462	.51	1309.	38.05
8.90	9002.	9133.	565.1	870.0	2.97	1106.
-4.14	1542.	.258	.4534	.51	1306.	38.34
9.00	9058.	9188.	561.7	889.3	2.97	1093.
-4.47	1538.	.255	.4605	.51	1303.	38.63
9.10	9114.	9242.	558.2	908.8	2.97	1079.
-4.79	1533.	.252	.4676	.50	1300.	38.92
9.20	9169.	9296.	554.9	928.4	2.97	1066.
-5.12	1528.	.249	.4748	.50	1297.	39.21
9.30	9224.	9349.	551.6	948.3	2.97	1054.
-5.46	1523.	.246	.4819	.50	1294.	39.49
9.40	9279.	9402.	548.4	968.4	2.97	1041.
-5.79	1518.	.244	.4890	.49	1291.	39.77
9.50	9333.	9455.	545.2	988.6	2.97	1029.
-6.12	1512.	.241	.4960	.49	1288.	40.04

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET QE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME THETA	X Z	DIST DRAG	V YAW	DH MACH	CMA SPIN	ENG SG
9.60	9387.	9508.	542.1	1009.0	2.97	1018.
-6.46	1506.	.238	.5031	.49	1285.	40.32
9.70	9441.	9560.	539.0	1029.7	2.97	1006.
-6.80	1500.	.235	.5101	.49	1282.	40.59
9.80	9495.	9611.	536.0	1050.5	2.97	995.
-7.14	1494.	.233	.5171	.48	1279.	40.85
9.90	9548.	9663.	533.1	1071.5	2.97	984.
-7.48	1487.	.230	.5240	.48	1277.	41.11
10.00	9600.	9714.	530.2	1092.7	2.97	974.
-7.83	1480.	.228	.5309	.48	1274.	41.37
10.10	9653.	9764.	527.4	1114.1	2.97	963.
-8.17	1472.	.226	.5378	.48	1271.	41.63
10.20	9705.	9815.	524.6	1135.7	2.97	953.
-8.52	1465.	.223	.5446	.47	1268.	41.88
10.30	9756.	9865.	521.9	1157.4	2.97	943.
-8.87	1457.	.221	.5513	.47	1266.	42.13
10.40	9808.	9914.	519.2	1179.4	2.97	934.
-9.22	1449.	.219	.5580	.47	1263.	42.37
10.50	9859.	9963.	516.5	1201.5	2.97	924.
-9.57	1440.	.217	.5646	.47	1260.	42.61
10.60	9910.	10012.	514.0	1223.9	2.97	915.
-9.92	1431.	.215	.5712	.46	1258.	42.84
10.70	9960.	10061.	511.4	1246.4	2.97	906.
-10.27	1422.	.213	.5777	.46	1255.	43.07

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET QE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME THETA	X Z	DIST DRAG	V YAW	DH MACH	CMA SPIN	ENG SG
10.80	10010.	10110.	509.0	1269.1	2.97	897.
-10.63	1413.	.211	.5841	.46	1252.	43.30
10.90	10060.	10158.	506.5	1292.0	2.97	889.
-10.99	1404.	.209	.5905	.46	1250.	43.52
11.00	10110.	10205.	504.1	1315.0	2.97	880.
-11.34	1394.	.207	.5967	.45	1247.	43.74
11.10	10159.	10253.	501.8	1338.3	2.97	872.
-11.70	1384.	.205	.6029	.45	1244.	43.95
11.20	10208.	10300.	499.5	1361.7	2.97	864.
-12.06	1374.	.203	.6089	.45	1242.	44.15
11.30	10257.	10347.	497.3	1385.3	2.97	856.
-12.42	1363.	.201	.6149	.45	1239.	44.36
11.40	10305.	10393.	495.1	1409.1	2.97	849.
-12.79	1352.	.200	.6208	.45	1237.	44.55
11.50	10353.	10440.	492.9	1433.1	2.97	841.
-13.15	1341.	.198	.6266	.44	1234.	44.75
11.60	10401.	10486.	490.8	1457.3	2.97	834.
-13.51	1330.	.196	.6322	.44	1232.	44.93
11.70	10449.	10532.	488.7	1481.6	2.97	827.
-13.88	1318.	.195	.6378	.44	1229.	45.12
11.80	10496.	10577.	486.7	1506.2	2.97	820.
-14.25	1306.	.193	.6432	.44	1227.	45.29
11.90	10543.	10622.	484.7	1530.9	2.97	814.
-14.61	1294.	.192	.6486	.44	1224.	45.47

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET QE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME	X	DIST	V	DH	CMA	ENG
THETA	Z	DRAG	YAW	MACH	SPIN	SG
12.00	10590.	10667.	482.7	1555.8	2.97	807.
-14.98	1282.	.190	.6538	.43	1222.	45.63
12.10	10636.	10712.	480.8	1580.8	2.97	801.
-15.35	1269.	.189	.6588	.43	1219.	45.79
12.20	10683.	10756.	479.0	1606.1	2.97	795.
-15.72	1256.	.188	.6638	.43	1217.	45.95
12.30	10729.	10800.	477.1	1631.5	2.97	788.
-16.09	1243.	.186	.6686	.43	1215.	46.10
12.40	10774.	10844.	475.4	1657.1	2.97	783.
-16.46	1230.	.185	.6733	.43	1212.	46.25
12.50	10820.	10888.	473.6	1682.9	2.97	777.
-16.84	1216.	.184	.6778	.43	1210.	46.38
12.60	10865.	10931.	471.9	1708.8	2.97	771.
-17.21	1202.	.182	.6822	.42	1208.	46.52
12.70	10910.	10974.	470.2	1734.9	2.97	766.
-17.58	1188.	.181	.6865	.42	1205.	46.65
12.80	10955.	11017.	468.6	1761.2	2.97	760.
-17.96	1174.	.180	.6906	.42	1203.	46.77
12.90	10999.	11060.	467.0	1787.7	2.97	755.
-18.33	1159.	.179	.6945	.42	1200.	46.89
13.00	11043.	11102.	465.4	1814.4	2.97	750.
-18.71	1145.	.178	.6983	.42	1198.	47.00
13.10	11087.	11145.	463.9	1841.2	2.97	745.
-19.08	1130.	.177	.7020	.42	1196.	47.10

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET QE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME THETA	X Z	DIST DRAG	V YAW	DH MACH	CMA SPIN	ENG SG
13.20	11131.	11187.	462.4	1868.2	2.97	740.
-19.46	1114.	.176	.7055	.42	1194.	47.20
13.30	11174.	11228.	460.9	1895.4	2.97	736.
-19.83	1099.	.175	.7088	.41	1191.	47.30
13.40	11218.	11270.	459.5	1922.7	2.97	731.
-20.21	1083.	.174	.7120	.41	1189.	47.38
13.50	11261.	11311.	458.1	1950.2	2.97	727.
-20.59	1067.	.173	.7150	.41	1187.	47.47
13.60	11303.	11352.	456.8	1977.9	2.97	723.
-20.96	1051.	.172	.7179	.41	1184.	47.54
13.70	11346.	11393.	455.4	2005.8	2.97	718.
-21.34	1034.	.171	.7205	.41	1182.	47.61
13.80	11388.	11434.	454.2	2033.8	2.97	714.
-21.72	1018.	.170	.7231	.41	1180.	47.68
13.90	11430.	11474.	452.9	2062.0	2.97	710.
-22.09	1001.	.169	.7254	.41	1178.	47.74
14.00	11472.	11514.	451.7	2090.4	2.97	707.
-22.47	984.	.168	.7276	.41	1176.	47.79
14.10	11514.	11554.	450.5	2118.9	2.97	703.
-22.85	966.	.168	.7296	.41	1173.	47.84
14.20	11555.	11594.	449.3	2147.6	2.97	699.
-23.22	949.	.167	.7315	.40	1171.	47.88
14.30	11596.	11634.	448.2	2176.4	2.97	696.
-23.60	931.	.166	.7332	.40	1169.	47.91

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET GE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME THETA	X Z	DIST DRAG	V YAW	DH MACH	CMA SPIN	ENG SG
14.40	11637.	11673.	447.1	2205.5	2.97	692.
-23.98	913.	.165	.7347	.40	1167.	47.94
14.50	11678.	11712.	446.0	2234.7	2.97	689.
-24.36	894.	.165	.7360	.40	1165.	47.97
14.60	11719.	11751.	444.9	2264.0	2.97	686.
-24.73	876.	.164	.7372	.40	1162.	47.99
14.70	11759.	11790.	443.9	2293.6	2.97	683.
-25.11	857.	.163	.7382	.40	1160.	48.00
14.80	11799.	11829.	442.9	2323.3	2.97	679.
-25.48	838.	.163	.7390	.40	1158.	48.01
14.90	11839.	11867.	442.0	2353.1	2.97	677.
-25.86	819.	.162	.7397	.40	1156.	48.01
15.00	11879.	11905.	441.0	2383.1	2.97	674.
-26.23	800.	.162	.7402	.40	1154.	48.00
15.10	11918.	11944.	440.1	2413.3	2.97	671.
-26.61	780.	.161	.7405	.40	1152.	47.99
15.20	11957.	11981.	439.3	2443.6	2.97	668.
-26.98	760.	.160	.7407	.39	1150.	47.98
15.30	11996.	12019.	438.4	2474.1	2.97	666.
-27.36	740.	.160	.7407	.39	1148.	47.96
15.40	12035.	12057.	437.6	2504.8	2.97	663.
-27.73	720.	.159	.7405	.39	1145.	47.93
15.50	12074.	12094.	436.8	2535.6	2.97	661.
-28.10	700.	.159	.7402	.39	1143.	47.90

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET QE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME THETA	X Z	DIST DRAG	V YAW	DH MACH	CMA SPIN	ENG SG
15.60	12112.	12131.	436.0	2566.6	2.97	658.
-28.47	679.	.159	.7397	.39	1141.	47.86
15.70	12150.	12168.	435.3	2597.7	2.97	656.
-28.85	658.	.158	.7391	.39	1139.	47.82
15.80	12188.	12205.	434.5	2629.0	2.97	654.
-29.22	637.	.158	.7383	.39	1137.	47.77
15.90	12226.	12242.	433.8	2660.5	2.97	652.
-29.59	616.	.157	.7373	.39	1135.	47.72
16.00	12264.	12278.	433.1	2692.1	2.97	650.
-29.95	594.	.157	.7362	.39	1133.	47.66
16.10	12301.	12315.	432.5	2723.8	2.97	648.
-30.32	572.	.157	.7350	.39	1131.	47.60
16.20	12339.	12351.	431.9	2755.8	2.97	646.
-30.69	550.	.156	.7336	.39	1129.	47.53
16.30	12376.	12387.	431.3	2787.8	2.97	644.
-31.06	528.	.156	.7320	.39	1127.	47.46
16.40	12412.	12423.	430.7	2820.1	2.97	642.
-31.42	506.	.156	.7303	.39	1125.	47.39
16.50	12449.	12458.	430.1	2852.4	2.97	641.
-31.79	483.	.155	.7285	.39	1123.	47.30
16.60	12486.	12494.	429.6	2885.0	2.97	639.
-32.15	461.	.155	.7265	.39	1121.	47.22
16.70	12522.	12529.	429.0	2917.6	2.97	637.
-32.51	438.	.155	.7244	.39	1119.	47.13

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET QE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME	X	DIST	V	DH	CMA	ENG
THETA	Z	DRAG	YAW	MACH	SPIN	SG
16.80	12558.	12565.	428.5	2950.5	2.97	636.
-32.88	414.	.154	.7222	.38	1117.	47.03
16.90	12594.	12600.	428.1	2983.5	2.97	635.
-33.24	391.	.154	.7198	.38	1115.	46.93
17.00	12630.	12635.	427.6	3016.6	2.97	633.
-33.60	367.	.154	.7173	.38	1113.	46.83
17.10	12665.	12670.	427.2	3049.9	2.97	632.
-33.95	344.	.154	.7147	.38	1111.	46.72
17.20	12700.	12704.	426.7	3083.3	2.97	631.
-34.31	320.	.154	.7119	.38	1109.	46.60
17.30	12736.	12739.	426.3	3116.9	2.97	629.
-34.67	296.	.153	.7090	.38	1107.	46.49
17.40	12771.	12773.	425.9	3150.6	2.97	628.
-35.02	271.	.153	.7061	.38	1105.	46.37
17.50	12805.	12808.	425.6	3184.4	2.97	627.
-35.38	247.	.153	.7030	.38	1103.	46.24
17.60	12840.	12842.	425.2	3218.5	2.97	626.
-35.73	222.	.153	.6998	.38	1101.	46.11
17.70	12874.	12876.	424.9	3252.6	2.97	625.
-36.08	197.	.153	.6965	.38	1099.	45.98
17.80	12909.	12910.	424.6	3286.9	2.97	624.
-36.43	172.	.153	.6931	.38	1097.	45.85
17.90	12943.	12944.	424.3	3321.3	2.97	624.
-36.78	147.	.153	.6896	.38	1095.	45.71

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET QE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

TIME	X	DIST	V	DH	CMA	ENG
THETA	Z	DRAG	YAW	MACH	SPIN	SG
18.00	12977.	12977.	424.0	3355.9	2.97	623.
-37.13	121.	.153	.6860	.38	1093.	45.56
18.10	13010.	13011.	423.8	3390.7	2.97	622.
-37.47	95.	.152	.6823	.38	1091.	45.42
18.20	13044.	13044.	423.5	3425.5	2.97	621.
-37.82	70.	.152	.6785	.38	1089.	45.27
18.30	13077.	13077.	423.3	3460.5	2.97	621.
-38.16	44.	.152	.6746	.38	1087.	45.11
18.40	13110.	13110.	423.1	3495.7	2.97	620.
-38.50	17.	.152	.6707	.38	1085.	44.96

TIME,SEC	RANGE,FT	VEL,FPS	THETA	SPIN	SG
18.47	13102.0	422.9	-38.8	1083.	44.96

TRAJECTORY TABLE NUMBER 1 (CON'T)

BALLISTIC DATA

PROJECTILE DIAMETER	20.00 MILLIMETER
PROJECTILE LENGTH	3.8 CALIBERS
PROJECTILE WEIGHT	.222857D POUNDS
	1560.00 GRAINS
	101.09 GRAMS
AXIAL MOMENT OF INERTIA	.0187466 POUND-INCH SQ.
TRANSVERSE MOMENT OF INERTIA	.1397623 POUND-INCH SQ.
AXIAL RADIUS OF GYRATION	.3683433 CALIBERS
TRANSVERSE RADIUS OF GYRATION	1.0057418 CALIBERS
CENTER OF GRAVITY, FROM BASE	1.513 INCHES
MUZZLE VELOCITY	3360.0 FEET/SECOND
BARREL TWIST	25.40050 CALIBERS/TURN
RIFLING EXIT ANGLE	7 DEGREES 3 MINUTES
YAW-DRAG COEFFICIENT, PER RADIAN SQUARED	5.8
ROLL DAMPING MOMENT COEFFICIENT, PER RAD/SEC	-.0100

TRAJECTORY TABLE NUMBER 1 (CON'T)

ALTITUDE: .0 FEET QE: 15.0 DEGREES

VELOCITY: .0 KTAS TEMP: 59.0 DEG F

DRAG COEFFICIENT AND STATIC MOMENT COEFFICIENT TABLE

MACH	CDO	MACH	CMA
.80	.211	.80	2.970
.90	.258	.90	3.100
1.00	.440	.97	3.190
1.12	.551	1.00	3.110
1.20	.558	1.20	2.850
1.50	.522	1.50	2.590
1.70	.500	1.70	2.460
2.00	.470	1.99	2.290
2.30	.438	2.25	2.160
2.50	.420	2.50	2.040
3.00	.393	3.00	1.890
3.60	.383	3.60	1.830

LEGEND

TIME	TIME OF FLIGHT, SECONDS
X	HORIZONTAL RANGE, FEET
DIST	SLANT RANGE, FEET
V	VELOCITY, FEET/SECOND
DH	GRAVITY DROP, FEET
CMA	STATIC MOMENT COEFFICIENT
ENG	ENERGY, FOOT-POUNDS
THETA	IMPACT ANGLE, DEGREES
Z	ALTITUDE, FEET
DRAG	DRAG, POUNDS
YAW	YAW OF REPOSE, DEGREES
MACH	MACH NUMBER
SPIN	REVOLUTIONS/SECOND
SG	GYROSCOPIC STABILITY FACTOR
TEMP	SURFACE (MSL) TEMPERATURE
Q.E.	DIVE ANGLE, DEGREES

Appendix F

TYPICAL TRAJECTORY TABLE INPUT

This input deck was used to generate the trajectory table shown in Appendix E. (See Table 1 for definition of input parameters.)

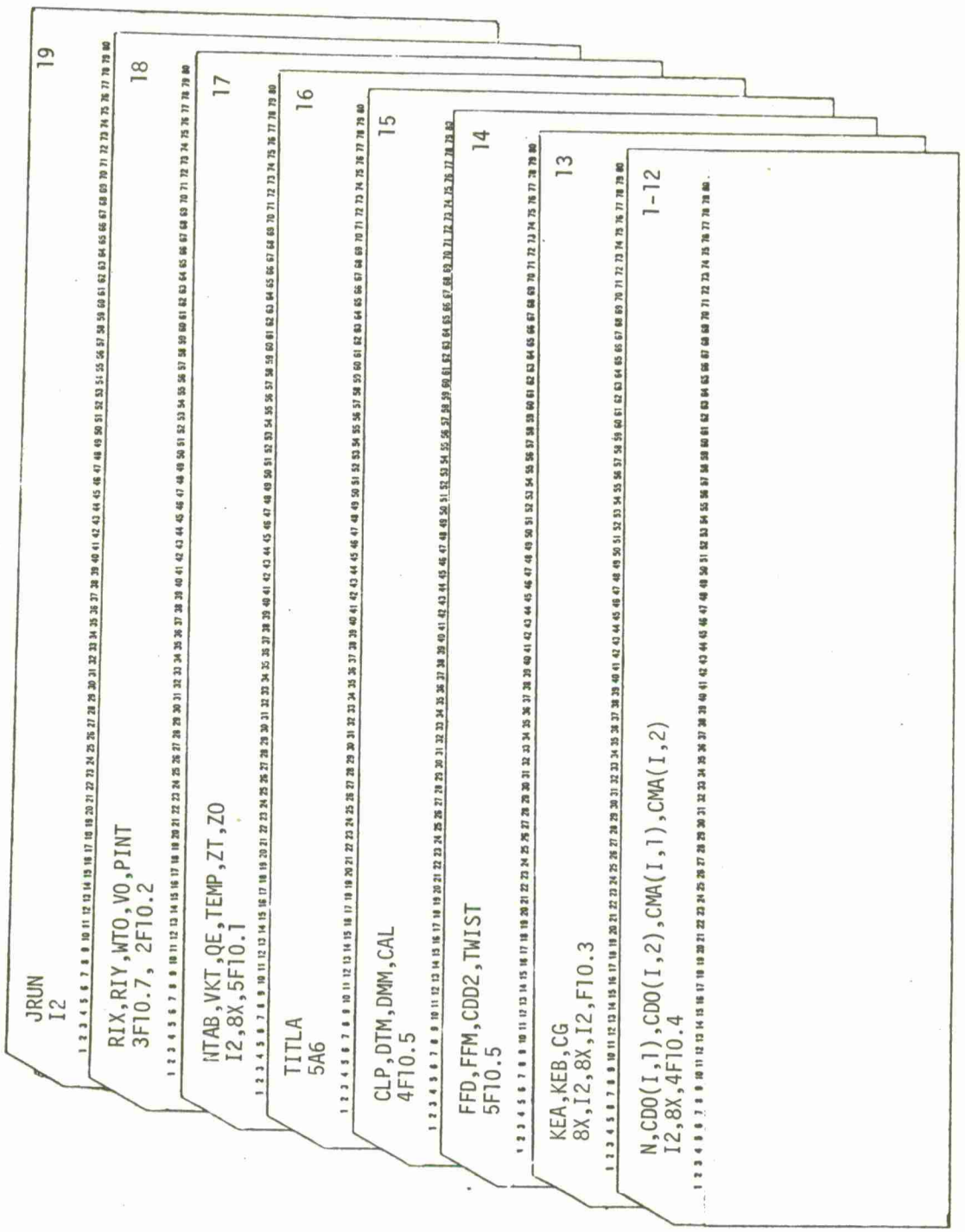


FIGURE F-1. Input Data Deck, Parameters.

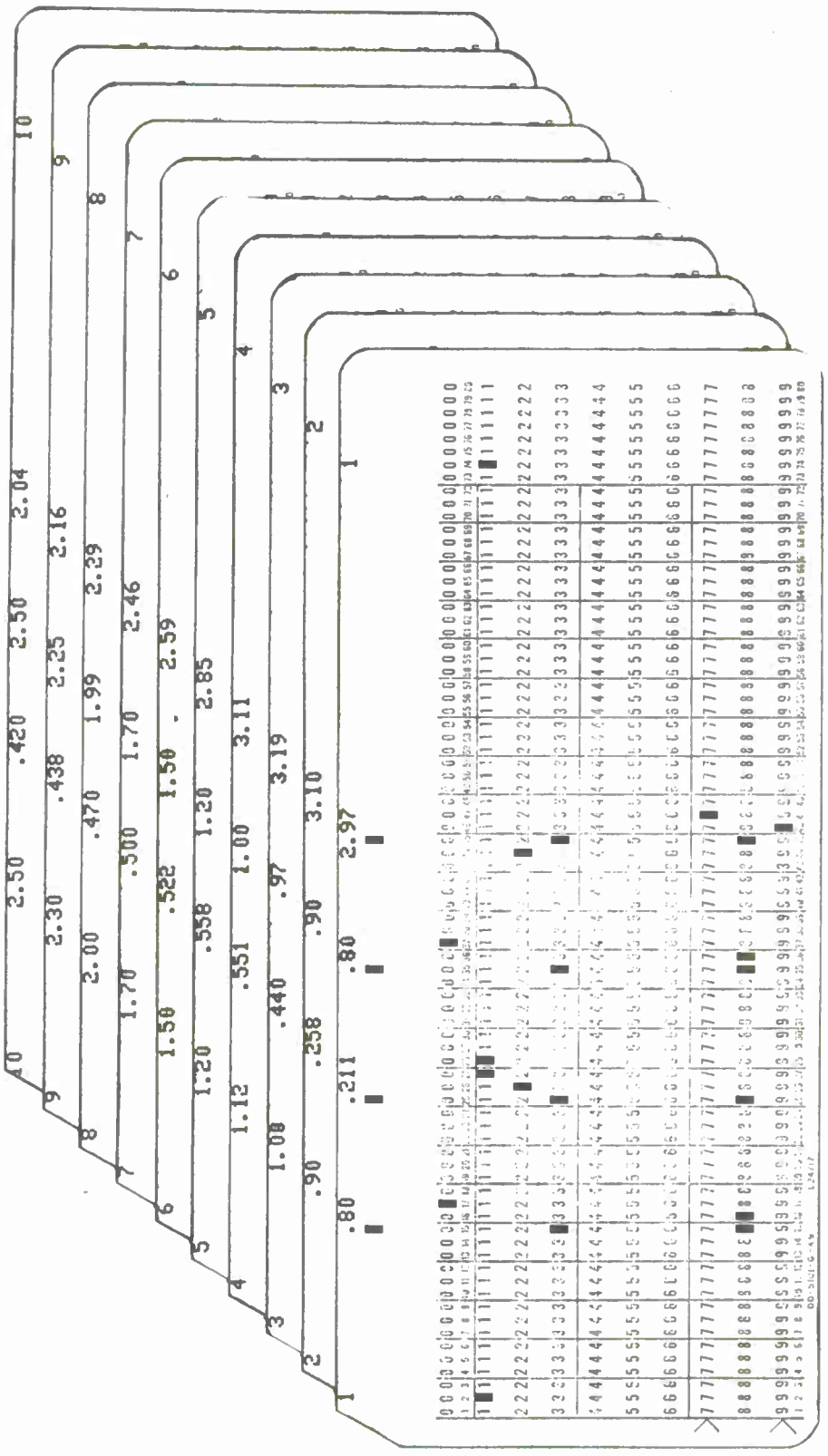


FIGURE F-2. Typical Input Data Deck, Cards 1 Through 19.

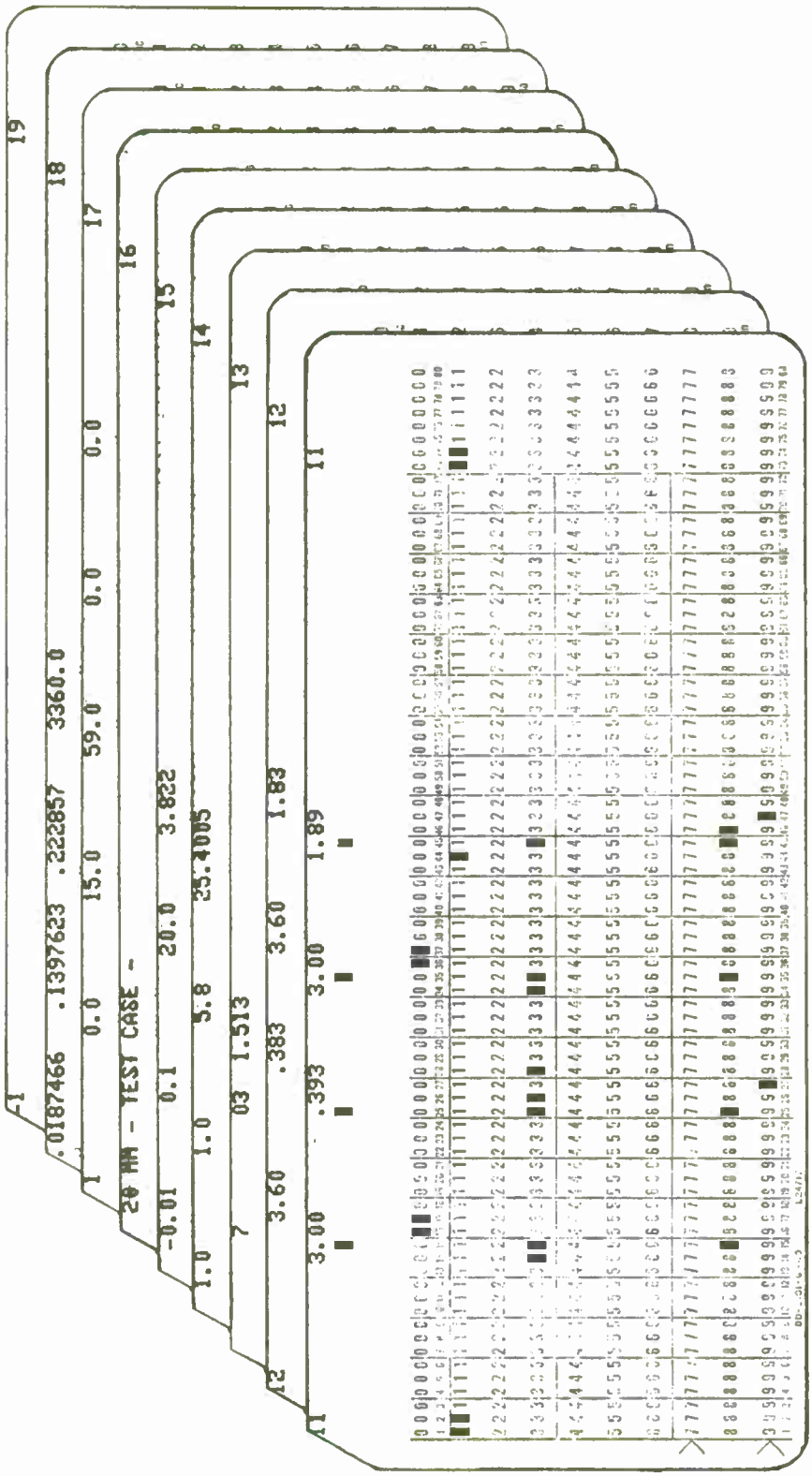


FIGURE F-2. (Contd.)

INITIAL DISTRIBUTION

3 Naval Air Systems Command
  AIR-350 (1)
  AIR-954 (2)
2 Naval Sea Systems Command
  SEA-09G32
1 Naval Surface Weapons Center, Dahlgren Laboratory, Dahlgren (Attn: MIL)
1 Naval Surface Weapons Center, White Oak, Silver Spring, Md.
  Technical Library (1)
1 Army Ballistic Research Laboratories, Aberdeen Proving Ground
  Technical Library (1)
1 Frankford Arsenal (Technical Library)
1 Picatinny Arsenal (Technical Library)
1 Rock Island Arsenal (Technical Library)
1 Armament Development & Test Center, Eglin Air Force Base
  (Technical Library)
2 Defense Documentation Center